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Addressing climate change in cities through nature-based solutions: Cases beyond Europe in the Urban Nature Atlas

Report Prepared for the British Academy

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Executive summary

The British Academy, in partnership with the Environmental Sciences and Policy Department at the Central European University (CEU) and the Nature-based Solutions Initiative (NbSI) at the University of Oxford, supported the publication of two collections of nature-based solutions (NBS) implemented worldwide presented as digital maps. The collection prepared by CEU and building on the Urban Nature Atlas[1] (UNA) platform focused on urban NBS outside of Europe, while the map prepared by NbSI[2] focused on rural NBS.

Intended to increase awareness of nature-based climate solutions at the UNFCCC COP26 in Glasgow and the upcoming COP27 in Sharm el-Sheikh, the global extension of the UNA focused on the identification of high-quality NBS projects which address *both* climate change mitigation/adaptation and biodiversity loss while delivering additional socio-economic benefits.

Key insights from urban cases are presented in this report, reflecting what is being done on the ground, who is implementing and financing NBS, and the costs and benefits associated with the various projects – both intangible and measurable. The report is also complemented by an analysis of the potential of NBS to tackle the climate crisis in developing countries

[1] https://una.city
[2] https://casestudies.naturebasedsolutionsinitiative.org

1. Introduction

Nature-based solutions (NBS) have the potential to facilitate the sustainability transformation of cities, making them more liveable and more resilient to the impacts of climate change. As a knowledge base dedicated to showcasing the richness and value of NBS in cities worldwide, the Urban Nature Atlas (UNA)[3] was created to inform, inspire, and enable everyone interested in bringing the transformative power of NBS to bear on the cities of the future.[4] Profiling over 1000 projects from European cities and beyond, it is the most comprehensive database of urban NBS to date.

1.1. Research aims

The development of the UNA was started in 2017 in the context of the Naturvation project funded through the EU's Horizon 2020 programme. It was developed to collect evidence on the implementation of NBS initially in European cities and make the information available through an interactive online platform that included custom-developed search functions. In July 2021 a process was launched to expand the content of the UNA beyond Europe, with emphasis on NBS focused on climate change adaptation or mitigation and biodiversity conservation or restoration benefits. Collection of these cases was funded by the British Academy in preparation for the 2021 United Nations Climate Change Conference (COP26) in Glasgow. The global extension of the UNA aimed to support both the public and policymakers worldwide to explore the many ways in which communities are working with nature to deal with the causes and consequences of climate change across a diversity of different urban environments, ecosystems, and socio-economic and governance contexts.

1.2. Research questions

Building on the infrastructure of the UNA, the global extension involved the identification of 120 urban or peri-urban NBS cases in non-European cities, highlighting, in particular, their connections to climate change mitigation and adaptation. This report provides an overview of the results of the new round of data collection and addresses the following questions:

- Which urban sustainability challenges have NBS addressed in practice?

[3] https://una.city/

[4] The UNA was developed by the Central European University (CEU) in collaboration with the Ecologic Institute, and with further support being provided by Durham University. Initial data collection for the UNA was conducted during the period June - August 2017 by CEU, Lund University and Utrecht University and comprised a systematic survey of NBS in 100 European cities. After initial data collection, the content of the UNA database was regularly maintained, and all existing entries were reviewed and updated as of the period July - November 2020. Following culmination of the Naturvation project in May 2021, the UNA transitioned from the Naturvation website to its new and permanent location at www.una.city. The UNA is now managed by a research team based within the Environmental Science and Policy Department at CEU. Work to extend the UNA database to include more projects is a continuing process.

- What types of urban settings are NBS implemented in, and what is the scope of their implementation?
- How do urban NBS projects address climate change mitigation and adaptation in practice?
- How are urban NBS projects managed and financed?
- What benefits have NBS delivered, or what benefits are they expected to deliver?
- What are the impacts and the effectiveness of urban and peri-urban NBS related to climate change adaptation in middle and low-income economies?
- What are those implementation and governance factors that increase the potential of cases to address climate objectives?
- What lessons can be drawn for policy making and the planning and implementation of NBS in the future?

1.3. Case identification and data collection approach

Cases added to the UNA during the global extension had to fulfil the general case selection criteria of the UNA: address various urban societal challenges; have features which change or enhance the function(s) of an area/structure; and use nature as an inspiration to address one or more urban problems, manifesting as either a physical or a discursive intervention (e.g., educational activities, management solutions).

The new cases were expected to have a primary focus on climate change mitigation/adaptation but also address biodiversity challenges. To ensure representative sampling, cases were selected in geographically and socio-economically diverse urban contexts and at different scales. Many cases identified by participants of a series of British Academy workshops in the summer of 2021 were also included.

We characterised NBS based on secondary sources such as project reports, websites, and news articles. Data was identified via text and discourse analysis of relevant, factual texts. All source materials are fully referenced. Data was collected by trained graduate or post-graduate students, and submitted via an online questionnaire, and was subsequently verified in two stages by the UNA project team prior to its publication on the UNA platform.[5]

As a result of the data collection, 120 non-European NBS cases from 85 countries were added to the UNA, as shown on Figure 1.

[5] The UNA data collection questionnaire gathers: general information about the project such as location and implementation timeline; sustainability challenges which the project aims to address; implementation activities; key characteristics of the project including its urban setting(s); an indication of the project's spatial scale; governance and financing details; a discussion of impacts achieved or expected to be achieved in connection to the project; and presentation of evidence of impact assessments and monitoring activities undertaken in relation to the project.

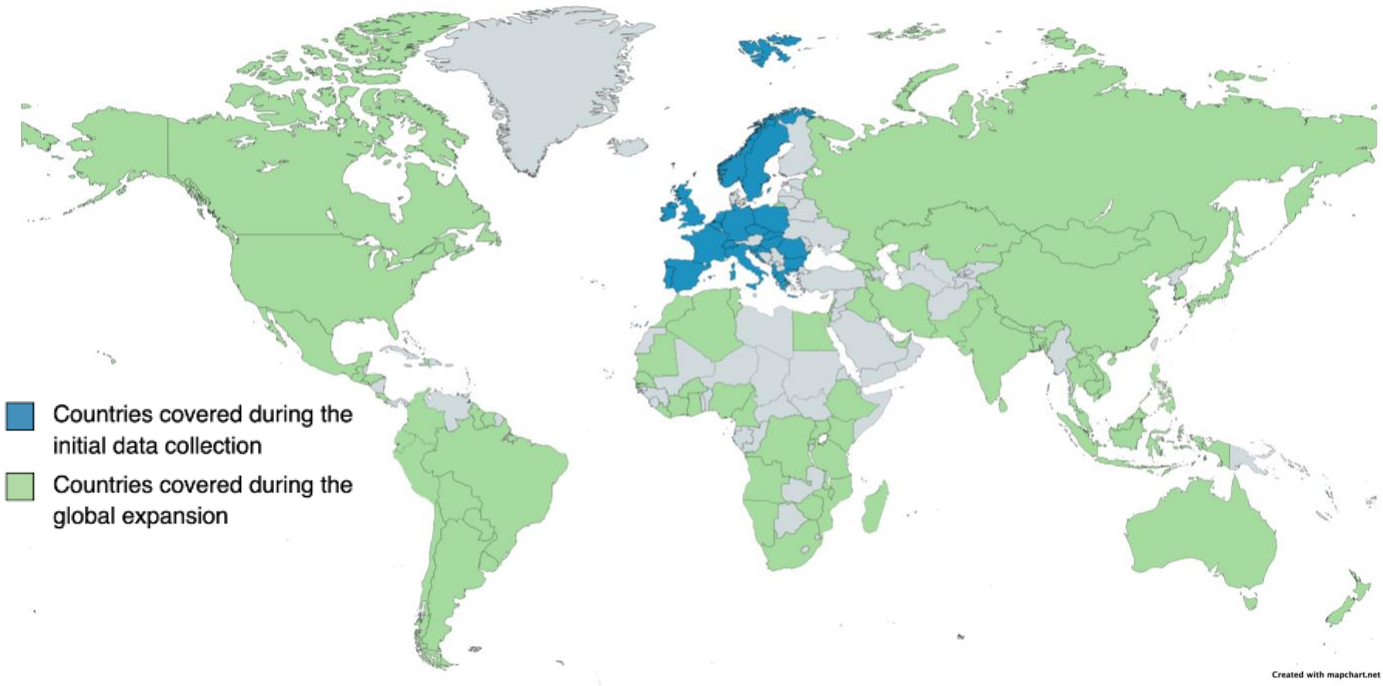

Figure 1. Countries for which NBS cases were added to the Urban Nature Atlas during its global extension ending in June 2022. Country coverage is illustrated based on whether case studies were included during the initial UNA data collection or during the UNA global extension.

2. Key lessons from NBS in non-European cities

Besides showcasing inspiring practices worldwide, the global extension of the UNA provided insights on NBS implementation patterns regarding the following: urban sustainability challenges addressed; urban settings of NBS and scope of their implementation; climate and biodiversity-related activities; governance, financing, and monitoring arrangements; and expected or actual impacts.

2.1. Which urban sustainability challenges have nature-based solutions addressed in practice?

NBS projects have potential to address multiple sustainability challenges, and these can be achieved in various ways.[6] According to the International Union for Conservation of Nature (IUCN), NBS comprise "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".[7] Implementing NBS may involve the creation of new green and blue spaces or the restoration of existing ones. In achieving this, NBS can support climate mitigation and adaptation, biodiversity and habitat protection, and flood and stormwater management or coastal protection, depending on their context. They can simultaneously advance nature-friendly landscape design; support job creation, eco-friendly agricultural and/or tourism development; reduce social inequalities and improve social cohesion; encourage participatory governance processes or improved management of natural resources; and aid the preservation of cultural and natural heritage. Box 1 provides an example of how NBS can address multiple urban sustainability challenges.

Box 1: Resilient Rosario (Argentina) provides a project example which illustrates how NBS can address multiple urban sustainability challenges.

Resilient Rosario is an ongoing urban and peri-urban agricultural programme. Through promotion of community gardens and allotments as NBS, it acts as Rosario city's response to increased flooding and heat events and tackles several further sustainability challenges via improvement of food security and nutrition for low-income residents through the strategic repurposing of both public land and private peri-urban spaces. It therefore promotes **sustainable consumption and production as well as social justice and equity**. The programme will additionally aid in reduction of carbon emissions and improved resilience to extreme weather events through promoting more compact food supply chains, addressing **climate**

[6] Raymond et al. (2017) *An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects.* Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas.

[7] Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). *Nature-based Solutions to address global societal challenges. Gland, Switzerland: IUCN. pxii*

change mitigation, and improving soil quality, preventing landslides and minimising flooding, improving **water management and environmental quality**. Through transforming derelict areas into green space, the programme contributes to **development of the local economy** by increasing local, sustainable food production. Identification of wastelands which could be converted into cultivation plots were undertaken in association with the city's residents, who also had access to urban farming classes and were involved in selection of vegetables to be cultivated. Since its inception, the project has now evolved into a larger-scale Green Belt Project which seeks to contain urban sprawl and achieve sustainable land restoration.

Source: Urban Nature Atlas https://una.city/nbs/rosario/resilient-rosario

Analysis of projects collected during the UNA global extension confirmed that NBS implemented in cities have significant potential to address multiple urban sustainability challenges, including those pertaining to climate change, biodiversity loss and human well-being. Revealing patterns similar to those European NBS projects previously included in the UNA,[8] the analysis of cases outside of Europe found that projects typically set four to six different goals concurrently (5 on average), and also that seven in ten NBS simultaneously address both environmental and social challenges.

Whilst the potential to address climate change and biodiversity challenges were prerequisites for case selection, it became apparent that the cases identified were also very likely to focus on water management issues (77%), such as those pertaining to flooding and stormwater. Of the 120 global projects, over half (54%) considered environmental quality and almost half (43%) focused on social equity challenges. In addition, they also addressed a range of other challenges, including urban regeneration (29%), economic development (29%) and health and well-being (27%), most of which are represented by specific sustainable development goals (SDGs). See Table 1 for examples.

Table 1. Urban sustainability challenges (and relevant United Nations Sustainable Development Goals (SDGs)) addressed by non-European NBS projects included in the UNA.

Urban Sustainability Challenge(s)	Number of Projects Addressing the Challenge(s)
Climate action for adaptation, resilience, and mitigation (SDG 13)	120
Green space, habitats, and biodiversity (SDG 15)	120
Water management (SDG 6)	92
Environmental quality	65
Social justice, cohesion, and equity (SDG 10)	52

[8] Almassy, D., Pinter, L., Rocha, S., Naumann, S., Davis, M., Abhold, K. and Bulkeley, H. (2018) *Urban Nature Atlas: A Database of Nature-Based Solutions Across 100 European Cities.* URL.

Regeneration, land-use, and urban development	35
Economic development and employment (SDG 8)	35
Health and well-being (SDG 3)	32
Cultural heritage and cultural diversity	19
Coastal resilience and marine protection (SDG 14)	18
Sustainable consumption and production (SDG 12)	14

2.2. What types of urban settings are NBS being implemented in, and what is the scope of their implementation?

NBS can take many forms in urban environments, and as urban spaces are neither uniform nor isolated (ecologically, physically, politically, economically, or socially), NBS are also featured across a multiplicity of different domains and landscapes.[9]

When considering the various urban settings around NBS, the Urban Nature Atlas considers both their ecological and the physical attributes. Table 2 provides an overview of the main types of NBS included in the database, with illustrative examples.

Table 2. Typology of nature-based solutions included in the UNA database with illustrative examples.

Parks and urban forests	
Large urban parks or forests;[10] pocket parks or neighbourhood green spaces; botanical gardens; green corridors.	**Ras Mekonnen Urban Park (Addis-Ababa, Ethiopia):**[11] As part of a larger intervention by Local Governments for Sustainability (ICLEI) and the Addis Ababa municipality, the Ras Mekonnen Urban Park was developed for the enjoyment of all residents of the Ras Makonnen neighbourhood. The Shega River was additionally rehabilitated. 
Blue infrastructure	

[9] Bulkeley, Harriet, and Raven, R. (2017). "Analysing Nature-Based Solutions for Urban Sustainability : Towards a Framework for NATURVATION Analysing Nature-Based Solutions for Urban Sustainability : Towards a Framework for NATURVATION Table of Contents," no. Naturvation Deliverable 1.6.

10 Large urban park or forests can include different features such as trees, grassy areas, playgrounds, water bodies, ornamental beds, etc.

[11] https://una.city/nbs/addis-ababa/ras-mekonnen-urban-park

Lakes/ponds; rivers/streams/canals/estuaries; deltas; coastlines (e.g., sand beaches, cliffs, sand dunes); wetlands/bogs/fens/marshes.	**East Kolkata Wetlands (India):**[12] This NBS focuses on management planning, intended to best aid the recovery of a degraded wetland, The goal of the planned management is to "maintain East Kolkata Wetlands in a healthy condition to enable the delivery of its full range of ecosystem services and sustain biological diversity values". 
Grey infrastructure with green features	
Alley and street trees/hedges/greens;[13] railroad banks and tracks; house gardens; green playgrounds/school grounds; institutional green spaces[14]; green parking lots; riverbank greens.	**The Green City Development (Shiraz, Iran):**[15] As a solution to increasing population, pollution and high energy consumption, the municipal government of Shiraz launched the Green City project in 2008 in order to reforest the city's periphery. 
Green areas for water management	
Rain gardens; swales/filter strips; sustainable urban drainage systems.	**Montevideo's Rain Gardens (Uruguay):**[16] Uruguay is highly vulnerable to climate change, and its cities are particularly vulnerable to the adverse effects of climate change (e.g. floods, extreme temperature fluctuations, hailstorms, frosts, heavy rains and severe storms). In 2018, the Montevideo municipality developed rain gardens to counteract the effects of heavy rain and potential flooding.

[12] https://una.city/nbs/kolkata/east-kolkata-wetlands-ekw

[13] Alley and street trees/hedges/greens can include hedges along roads or paths, shrubs or grassy verges along roads.

14 Institutional green space comprises green spaces surrounding public and private institutions and corporation buildings.

[15] https://una.city/nbs/shiraz/green-city-development

[16] https://una.city/nbs/montevideo/montevideos-rain-gardens

	
Community and allotment gardens	
Allotments; community gardens; horticulture; farmlands.	**Thammasat University Urban Rooftop Farm (Bangkok, Thailand)**:[17] Uniting principles of modern landscape design with the traditional agriculture of rice terraces, this project comprises Asia's largest organic rooftop farm and aims to transform wasted space into productive land. By mimicking traditional rice terraces, the project offers many collective solutions as it serves as public green space, an urban organic food source, a water management system, an energy house, and an outdoor classroom. 
Nature on buildings	
Green roofs;[18]; green walls or facades,[19] balcony greens (pot plants).	**Santalaia Building Vertical Garden (Colombia):**[20] The Santalaia Building is a high-end, multi-family residential building located in the heart of downtown Bogota, Colombia. Construction of the 11-story building culminated in 2015, with each floor being engulfed in multiple plant species to encourage biodiversity. The building is often referred to as "the green heart of Bogota" and is seen as an icon of sustainability.

[17] https://una.city/nbs/bangkok/thammasat-university-urban-rooftop-farm-turf

[18] Green roofs can include perennials, grasses, small trees, rooftop farming, mosses, succulents, few herbs and grasses.

19 Ground-based climbing plants intended for ornamental purposes or plants growing in façade-bound.

20 https://una.city/nbs/bogota/santalaia-building-vertical-garden

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As regards to the type of the urban setting of NBS, over half of the non-European projects in the UNA concern parks and urban forests (57%) and/or blue areas (53%) such as rivers, wetlands, and coastal areas (Figure 2). An also relatively common phenomena appears to concern the greening of grey infrastructure (38%), such as promotion of street greens, riverbank greens, and green parking lots and playgrounds. Projects also involved promotion of green areas for water management (23%); community or allotment gardens (19%); and the greening of buildings (17%).

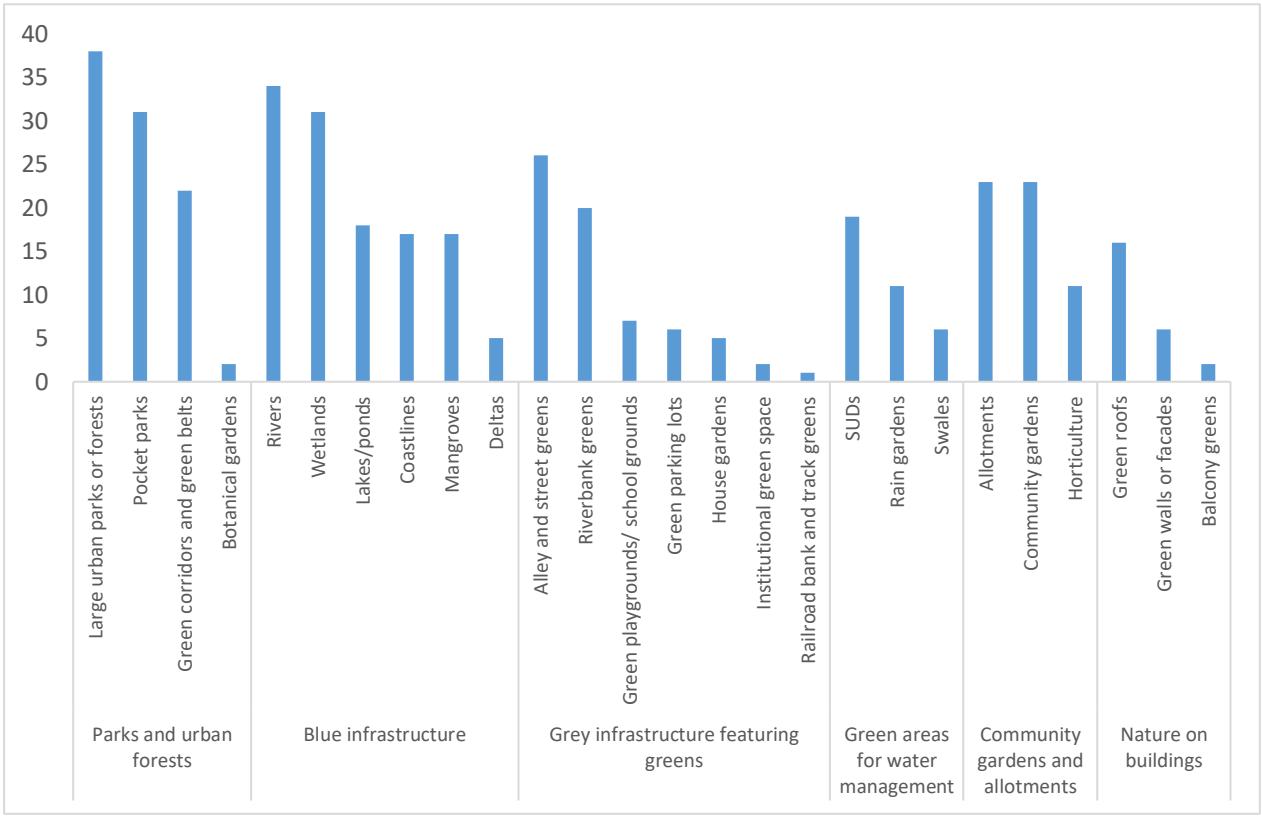

Figure 2. Urban settings of the non-European NBS projects included in the UNA.

Research suggests that NBS are most efficient and beneficial when applied systematically at a larger landscape scale.[21] Approximately 46% of non-European NBS cases included in the UNA refer to city scale project, and 41% targeted district/neighbourhood level implementation. The majority of cases were therefore implemented at a relatively large spatial scale, therein having higher potential for far-reaching benefits to be conferred. Through being implemented at such a relatively large spatial scale, the majority of NBS therefore spanned more than one type of urban setting and additionally concerned multiple implementation activities.

As regards implementation activities, most projects (91 out of the total 120) focused on the creation of green space in urban areas (see Figure 3). Ecological restoration of degraded ecosystems and protection of existing natural ecosystems were also common (51 and 29 cases, respectively).

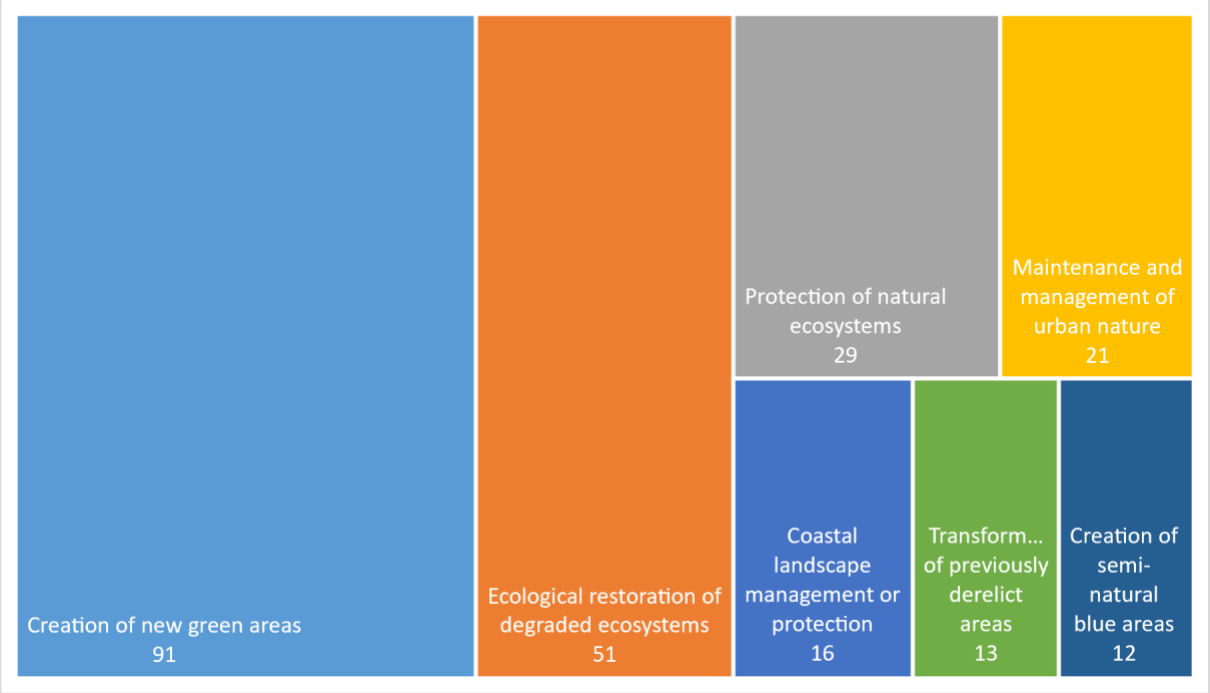

Figure 3. Scope of the implementation activities of the non-European NBS projects included in the UNA, broken down by type of physical intervention undertaken.

In addition, representing a physical NBS intervention, over half of the projects (77 out of the total 120) also involved discursive actions such as knowledge creation and transfer, strategy development, improved management of green/blue areas and promotion of habitat and biodiversity monitoring. Typically, such activities were not the primary focus, but accompanied physical interventions to strengthen their implementation.

[21] Barbara Sowińska-Świerkosz, Joan García (2022) What are Nature-based solutions (NBS)? Setting core ideas for concept clarification, *Nature-Based Solutions*, Volume 2, 2022.

2.3. How do urban NBS projects address climate change mitigation and adaptation in practice?

As the global extension of the UNA sought to include only high-quality NBS projects which actively and demonstrably address climate change associated challenges, each case featured climate objectives: 102 of the 120 projects referenced climate change adaptation, 49 referenced climate change mitigation, and 31 projects referenced both.

Climate change adaptation involved both physical or deliberative measures: prevent/manage desertification, soil erosion and landslides; capture/store water to increase water availability and reduce shortages associated with drought; increase urban vegetation cover and reduce outdoor temperatures; implement green walls or roofs to lower indoor temperatures and provide thermal insulation; implement sustainable urban drainage infrastructure; renaturalise rivers and other water bodies; restore wetlands and/or coastal ecosystems to dissipate the effects of flooding and/or storms; restore coastal ecosystems to mitigate coastal erosion and reduce pollution; and promote the cultivation of climate-resilient vegetation. Examples of climate adaptation related activities are presented in Table 3.

Table 3. Climate change adaptation activities pursued by the non-European NBS projects included in the UNA, broken down by activity type, and illustrated by a corresponding project example.

Climate Adaptation Activities	Project Description
Prevent/manage desertification, soil erosion and landslides	**Sponge City in San Salvador (El Salvador):** A city prone to droughts, floods and landslides, San Salvador's NBS project aims to improve rainwater infiltration, enhance storm-water drainage systems, and stabilise soil on the slopes of this volcanic region. Through restoration of both coffee plantations and forests, and via digging of infiltration ditches, the project seeks to reduce risks associated with landslides, erosion, and flooding.[22]
Capture/store water to increase its availability and prevent shortages associated with drought	**The Green Cloud Project (Shenzhen, China):** Construction of a green roof and rain garden featuring indigenous plants provides a nature-based stormwater management system for a residential building. Launched by The Nature Conservancy, the project seeks to promote absorption and preservation of rainwater.[23]
Increase or improve urban vegetation cover to help reduce outdoor temperature (mitigate the urban heat island effect)	**Greening in Laval (Canada):** To mitigate the urban heat island effect, community-led tree planting has sought to replace impermeable surfaces such as asphalt with vegetation in both public and private spaces. Various initiatives have been introduced to support this project.[24]
Implement green walls or	**eThekwini Municipality Green Roof Pilot (South Africa)**: One of several NBS

[22] https://una.city/nbs/san-salvador/sponge-city-san-salvador
[23] https://una.city/nbs/shenzhen/green-cloud-project-gangxia-1980
[24] https://una.city/nbs/laval/greening-laval

roofs to lower indoor temperature and provide insulation	projects designed to improve Durban city's resilience to future climate challenges, this green roof specifically aims to reduce the indoor temperature of the building on which it has been implemented, whilst simultaneously reducing the urban heat island effect.[25]
Implement sustainable urban drainage infrastructure (e.g., to make space for water)	**"Let's return the rivers to the city" (Izhevsk, Russia):** An ongoing public initiative, this NBS seeks to improve the ecological state of the Podborenka River, its embankment zone and the local biodiversity which is associated with the river and its riverbanks. It has also seen promotion of sustainable urban drainage systems.[26]
Renaturalise rivers and other water bodies	**Cheonggyecheon Stream Restoration Project (Seoul, South Korea):** Located in the historic centre of Seoul, this NBS project saw removal of an overhead freeway and subsequent opening of the Cheonggyecheon stream which had previously been encased. No longer underground, the stream has been renaturalised and multiple benefits achieved.[27]
Restore wetlands and/or coastal ecosystems to dissipate the effects of flooding and/or storms	**Mandaue City Mangrove Eco Park (Philippines):** Creation of a mangrove eco-park aims to provide flood protection, reinforce the shoreline, and improve its ability to buffer against strong winds and waves, and increase filtration to improve water quality.[28]
Protect coastal ecosystems to prevent coastal erosion and pollution	**Building coastal resilience (Muanda, Congo):** Having intensified since 1980, coastal erosion poses serious implications for community livelihoods in Muanda. The NBS project aims to support development of an Early Warning System for local communities which face coastal risk and includes implementation of land-planning and re-vegetation measures.
Increase the use of climate-resilient plant species (resistant to drought, fire, and pests)	**Preservation of tree species in Douala (Cameroon):** A city prone to flooding, Douala intends to simultaneously address the impacts of climate change and preserve its natural environment through protection and restoration of its local biodiversity. Implementation activities include seed germination of endangered tropical forest species, and cultivation of species which are adapted to the local environment and/or have medicinal properties.[29]

Regarding climate change mitigation, NBS focused on enhancing carbon storage (e.g., in wetlands or urban forest); promoting the cultivation of climate-adaptable/resilient species to enhance carbon sequestration; encouraging sustainable agriculture to minimise energy use and carbon emissions; implementing solutions to reduce energy consumption and/or promote the use of sustainable energy; and raising public awareness of behavioural, lifestyle and cultural change with climate change mitigation potential. Examples are presented in Table 4.

[25] https://una.city/nbs/durban/ethekwini-municipality-green-roof-pilot-project
[26] https://una.city/nbs/izhevsk/lets-return-rivers-city-campaign
[27] https://una.city/nbs/seoul/cheonggyecheon-stream-restoration-project
[28] https://una.city/nbs/mandaue/mandaue-city-mangrove-eco-park
[29] https://una.city/nbs/douala/preservation-tree-species-douala

Table 4. Climate change mitigation activities pursued by the non-European NBS projects included in the UNA, broken down by activity type, and illustrated by a corresponding project example.

Climate Mitigation Activities	Project Description
Increase urban nature for carbon storage (e.g., wetlands and tree cover)	**Mangrove Restoration Project (Georgetown, Guyana):** Through mangrove reforestation and forest preservation activities, this project aims to counteract several issues related to prior degradation and loss of mangrove forests and will provide climate change mitigation through carbon sequestration.[30]
Implement sustainable forest management measures to increase carbon sinks/improve carbon storage	**Sweet City - a city modelling approach for pollination (Curridabat, Costa Rica):** One of several climate-resilient and mitigation objectives, this NBS saw increased forestry cover within local parks and riverside forests across Curridabat, particularly aimed at increasing carbon sequestration and reducing the urban heat island effect throughout the city.[31]
Improve carbon sequestration through selection of more adaptable species	**Afforestation at the Gullele Botanical Garden (Addis Ababa, Ethiopia**): Part of a national campaign, this project focused on planting native, endangered and climate resistant plant species to mitigate climate change. Benefits provided include the increased absorption and storage of carbon dioxide and additional greenhouse gases.[32]
Support sustainable agricultural practices to reduce energy use and/or carbon emissions	**The Green Belt of Algiers (Algeria):** Still ongoing, this project seeks to preserve local agricultural and forestry activities, and supplement these with innovative sustainable approaches, amongst other objectives. Agro-parks, allotments and parks fall under the project scope, together intended to increase the productivity and profitability of agricultural activities.[33]
Implement solutions to reduce energy consumption or support the increased use of sustainable energy resources	**Sustainable Residential Complex Development (Dubai, United Arab Emirates):** This project seeks to reduce the ecological footprint of the city. It concerns the first operational residential complex in Dubai to achieve net zero energy.[34]
Raise public awareness of behavioural, lifestyle and cultural changes with mitigation potential	**Green Belt of Medellin (Colombia):** One of the key focal points of this project was an environmental education programme which aimed to explain to citizens which practices can reduce greenhouse gas emissions.[35]

2.4. How are urban NBS projects being managed and financed?

Based on the review of the new cases in the UNA, both local authorities and non-governmental actors play a pivotal role in the (re-)greening of cities and management of urban nature.[36] It appears that hybrid governance models, where governmental actors work closely with external stakeholders, are also gaining traction. Of the 120 non-European NBS case

[30] https://una.city/nbs/georgetown/guyanas-mangrove-restoration-project
[31] https://una.city/nbs/curridabat/sweet-city-city-modelling-approach-pollination
[32] https://una.city/nbs/addis-ababa/aforestation-gullele-botanical-garden
[33] https://una.city/nbs/algiers/green-belt-algiers
[34] https://una.city/nbs/dubai/sustainable-residential-complex-development
[35] https://una.city/nbs/medellin/green-belt-medellin
[36] Zingraff-Hamed et al. (2020). Governance models for nature-based solutions: Seventeen cases from Germany. Ambio. A Journal of the Human Environment 50 (8)

studies, 56 involved joint governance by different actors, 37 were government-led, and 27 were managed by non-governmental organisations.

The following are examples of governance set-ups encountered during the UNA global extension:

- **Government-led:** In Kolkata (India), unsustainable maintenance of the **East Kolkata Wetlands** precipitated a local authority to create a restoration and management project. Still ongoing, the initiative is entirely led by the Kolkata Municipal Corporation in response to three local regulations, namely the East Kolkata Wetlands Management Action Plan (2021 – 2026), Wetland Conservation and Management Rules (2017), and East Kolkata Wetlands (Conservation and Management) Act (2006). The project aims to better support treatment of the degraded wetlands, treatment of sewage via traditional waste recovery practices and maintenance of local biodiversity.[37]
- **Led by non-governmental actors:** Considered an icon of sustainability and the green heart of Bogota (Columbia), the **Santalaia Building Vertical Garden** houses 115,000 plants of 10 native species in a high-end, multi-family residential building. Its realisation was led by private actors, with the Colombian Company, Groncol, holding responsibility for its design and construction, and the Spanish Company, Paisajismo Urbano, providing technological support.[38]
- **Co-governance arrangement:** In 2017, the Auckland city government launched the **"Million Trees"** programme, which aimed to increase vegetation across the city. Multiple benefits were sought through implementation of the project: to make the city more aesthetically pleasing, to provide a natural solution to carbon absorption, to protect the city's waterways, and to improve the city's environment. Implementation of the project was a joint process, with a variety of actors being involved in the planting activities, including local boards, trusts, a local plant nursery, schools, service and social sector groups, private entities, the council group, and the New Zealand Transport Association.[39]

Regarding the financing of NBS, budget information was only available for half of the cases in the UNA global extension. Of those cases for which data was available, approximately 29% had a budget of less than EUR 500,000, 19% had a budget ranging from EUR 500,000 to EUR 4 million and approximately 52% had a budget exceeding EUR 4 million. Projects drew upon a variety of funding, with total funds typically originating from more than one source. Local authorities and multilateral funds were the most frequent funders of NBS projects, as shown in Figure 4. Funding provided by NGOs, as well as national and regional governments, was also associated with multiple projects. Innovative financing mechanisms were found to be rare.

[37] https://una.city/nbs/kolkata/east-kolkata-wetlands-ekw

[38] https://una.city/nbs/bogota/santalaia-building-vertical-garden

[39] https://una.city/nbs/auckland/million-trees

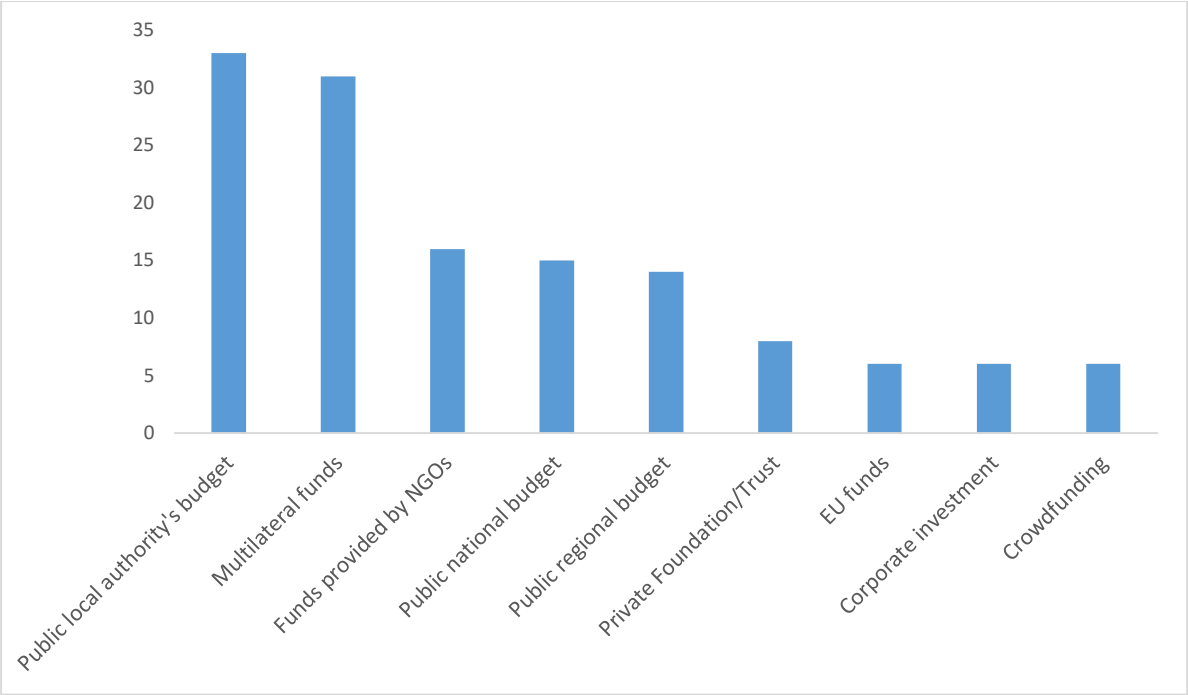

Figure 4. Type of funding sources drawn upon by the non-European NBS projects included in the UNA, illustrated by total number of projects per funding type.

Non-financial contributions can also be relatively important for the implementation and maintenance of NBS, as they can enhance their impact and long-term sustainability. Such contributions can involve provision of land, labour, expertise, or other services. Non-financial contributions were recorded in 46% of the cases. Box 2 provides an example of non-financial contributions to NBS implementation and maintenance.

Box 2: "One school, 5 hectares of forest" (Bingerville, Côte d'Ivoire) provides a project example which illustrates how non-financial contributions can support NBS implementation and maintenance.

The "One school, 5 hectares of forest" project sough to educate young children on their local environment, including its importance to Bingerville (Côte d'Ivoire), and the importance of caring for the recovery of forest cover. Initiated by the local high school in association with the Ministry of Water and Forests, the project was primarily financed by the national public budget, providing less than EUR 10,000. Several non-financial contributions were provided by citizens and public authorities, including the provision of land, labour, and volunteers' expertise. Project outcomes were enhanced carbon sequestration, increased prevalence of green space and biodiversity, and increased local knowledge regarding the local natural environment and the importance of conserving forests.

Source:https://una.city/nbs/bingerville/one-school-5-hectares-forest

2.5. What benefits have NBS delivered, or expected to deliver?

In order to enable better-informed policy and decision-making, both the outcomes and impacts of NBS must be monitored. Measurement helps verify impacts, assess NBS effectiveness, facilitates the identification of trade-offs and potential barriers to implementation, and may pinpoint options for improvements.

Only 58 of the total 120 cases had a formal monitoring system, of which 29 made their monitoring/evaluation report(s) available. Only 14 referred to using specific impact assessment tools. These results indicate that most projects do not have the preconditions for systematic impact assessment and reporting. Consequently, they miss out on potential opportunities related to demonstrating impacts and informing and improving the planning and implementation of NBS.[40] Lack of monitoring capacity and credible ex-post impact assessment - or ex-ante impact projection - may well reduce the interest of investors, policymakers or indeed the general public in supporting NBS development, whether in the public or private sector.

Despite the relative lack of adequately detailed, quantitative assessment of project impacts, it was nonetheless possible to identify environmental and socio-economic benefits through the analysis of NBS' self-reporting.

All non-European cases reported either achieved or expected impacts. 119 of the 120 identified both environmental and socio-cultural, and 71 also economic impacts. In percentage terms, 57.5% delivered impacts across all three (environmental, social-cultural or economic), while 42.5% across two impact fields.

When comparing with the 1000 European cases in the UNA, non-European NBS report a wider variety of impacts, with 57.5% reporting impacts across all three main impact categories, as opposed to only 36% in Europe. The collection of non-European cases focused exclusively on NBS projects which address both climate change and biodiversity. This was not a requirement for the original European cases in the Atlas. These European and non-European results are not directly comparable, given the different search criteria. However, the relatively high percentage of NBS that contribute across all three impact areas in the more purposive non-European sample suggest that the expectation that NBS can address – or multi-solve - a wider range of sustainability challenges simultaneously is valid.

A breakdown of impacts as self-reported by the non-European cases included in the UNA global extension is provided in Figure 5.

[40] Almassy D. (2022) *Realising the Potential of Nature-Based Solutions for a Transformative Societal Change.* British Academy

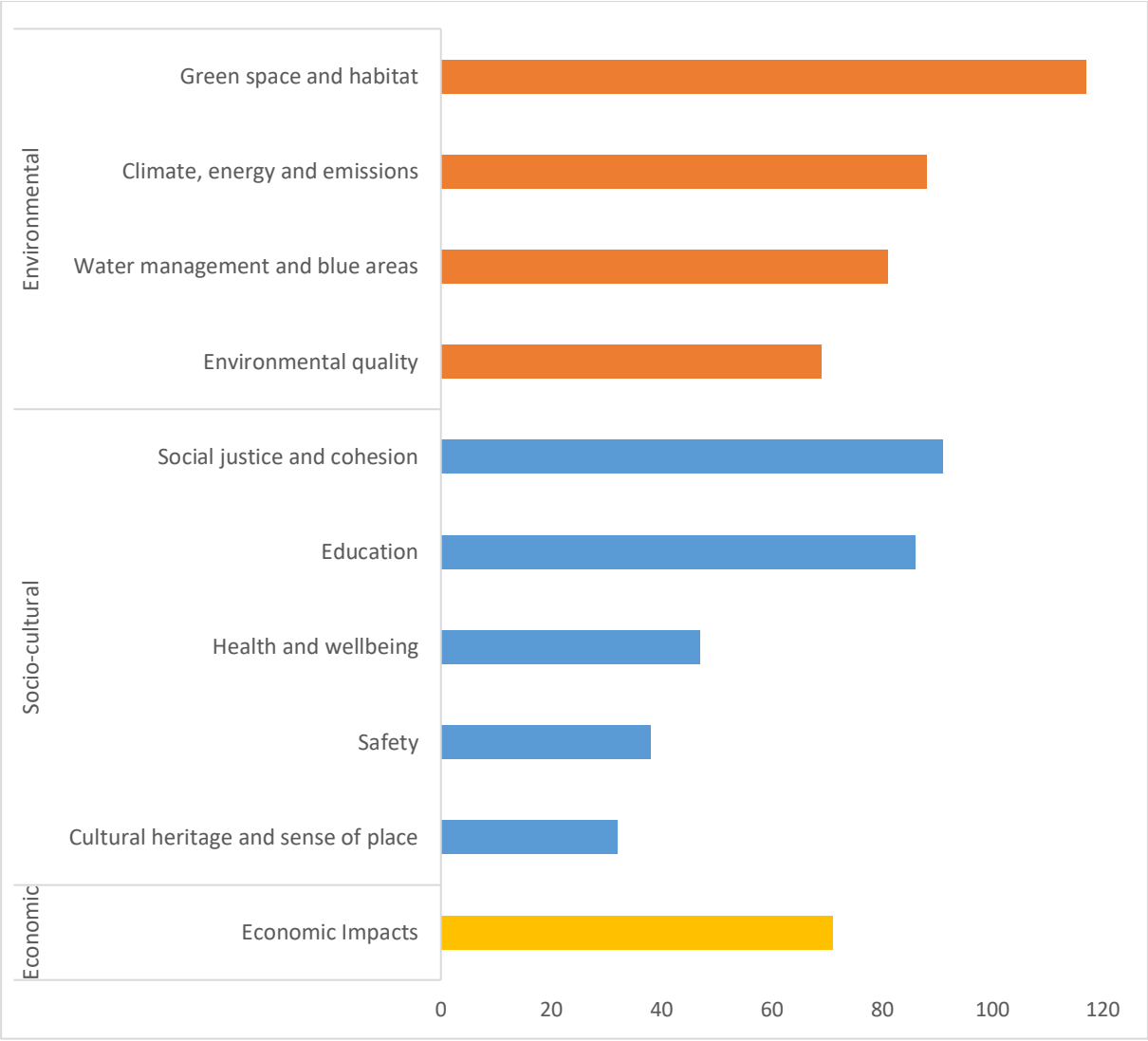

Figure 5. Benefits expected or achieved through implementation of the non-European NBS cases included in the UNA global extension.

A project example with self-reported multiple impacts is presented in Box 3.

Box 3: Green and resilient neighbourhood development (Hong Kong, Hong Kong SAR China) illustrates how multiple impacts can be achieved through NBS.

Ongoing since 2016, a neighbourhood development project in Hong Kong involves the transformation of a vacant 40-hectare plot into a sustainable residential neighbourhood. The project pursues climate resiliency and a low environmental impact, and involves installation of green roofs, street trees, parks, and sustainable urban drainage systems. The project is government-led and has been allocated a budget of EUR 4 million from the regional public budget. Expected benefits include a lowering of external temperatures, increased carbon sequestration, increased resilience to flooding incidents and therefore enhanced safety of the local community against climate-related hazards, increased available green space, increased

enablement of social interaction and cohesion, and provision of opportunities for physical activity and recreation.

Source: *https://una.city/nbs/hong-kong/green-and-resilient-neighbourhood-development*

2.5.1. Environmental impacts

98% of the 120 non-European projects reported biodiversity-relevant benefits achieved or anticipated to be achieved. Projects frequently cited increased green space (83%), increased number of species present (63%), reduced biodiversity loss (44%) and increased conservation or restoration of local habitats (35%). As shown on Figure 6, a selection of projects also promoted restoration of degraded areas, improvement of ecological connectivity and/or increased pollination support.

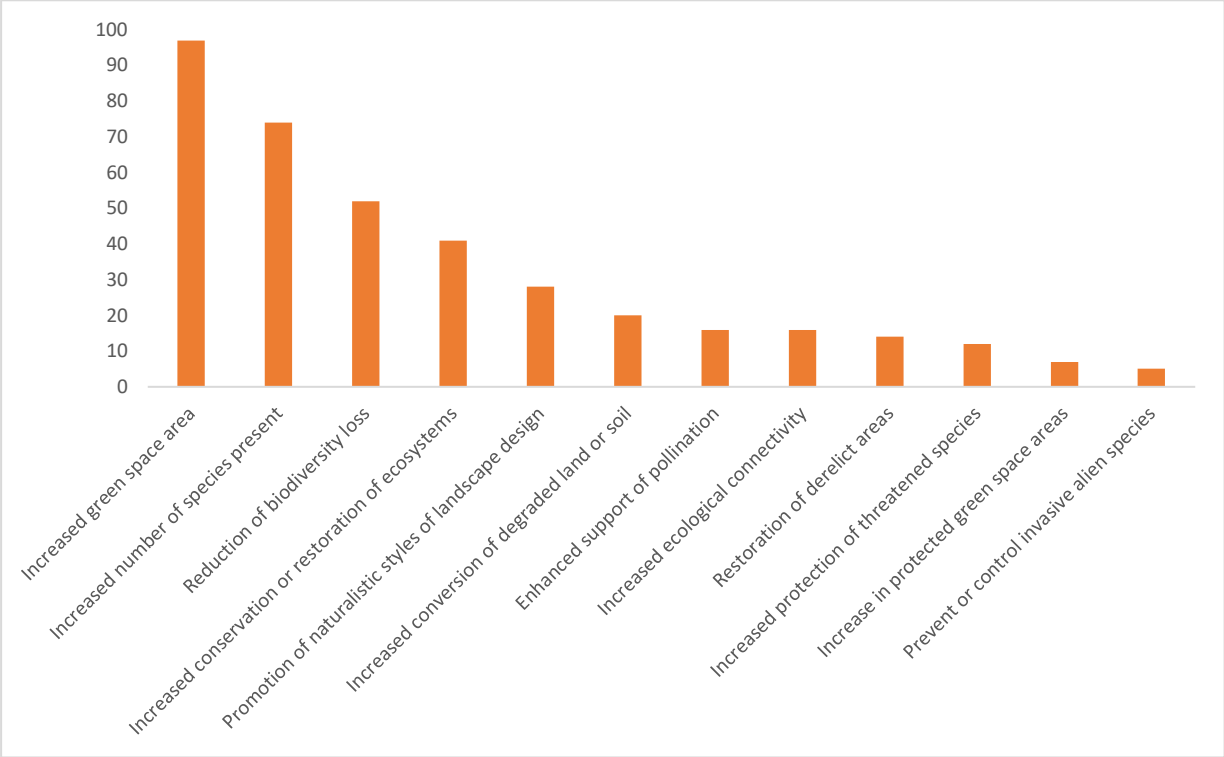

Figure 6. Impacts related to green space and habitat, reported by non-European NBS.

Whilst all non-European cases addressed climate change as a project objective, which was one of their key selection criteria for being included in the sample, 27% did not actually report climate-relevant impacts. Of the 73% of projects which did report climate-relevant benefits conferred by NBS, the following were reported as achieved or potential benefits (see Figure 7): lowering of external or internal temperature (51%); strengthened capacity of local communities to handle climate hazards/natural disasters (44%); enhanced carbon sequestration (41%); and reduced greenhouse gas emissions (9%).

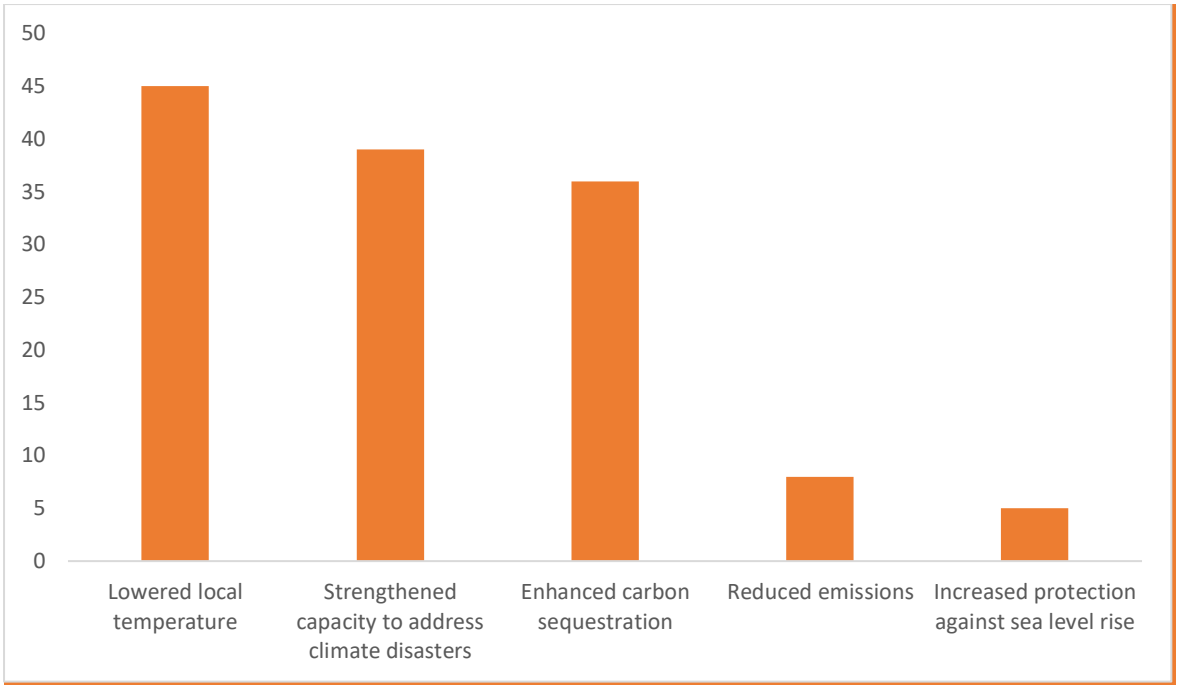

Figure 7. Achieved and/or expected impacts as reported by non-European NBS cases pertaining to climate change, energy and emissions.

68% of projects cited improved water management as a benefit of NBS implementation, with almost half of the projects reporting potential flood protection benefits (49%), and a third potential improvements in stormwater management (35%) (Figure 8).

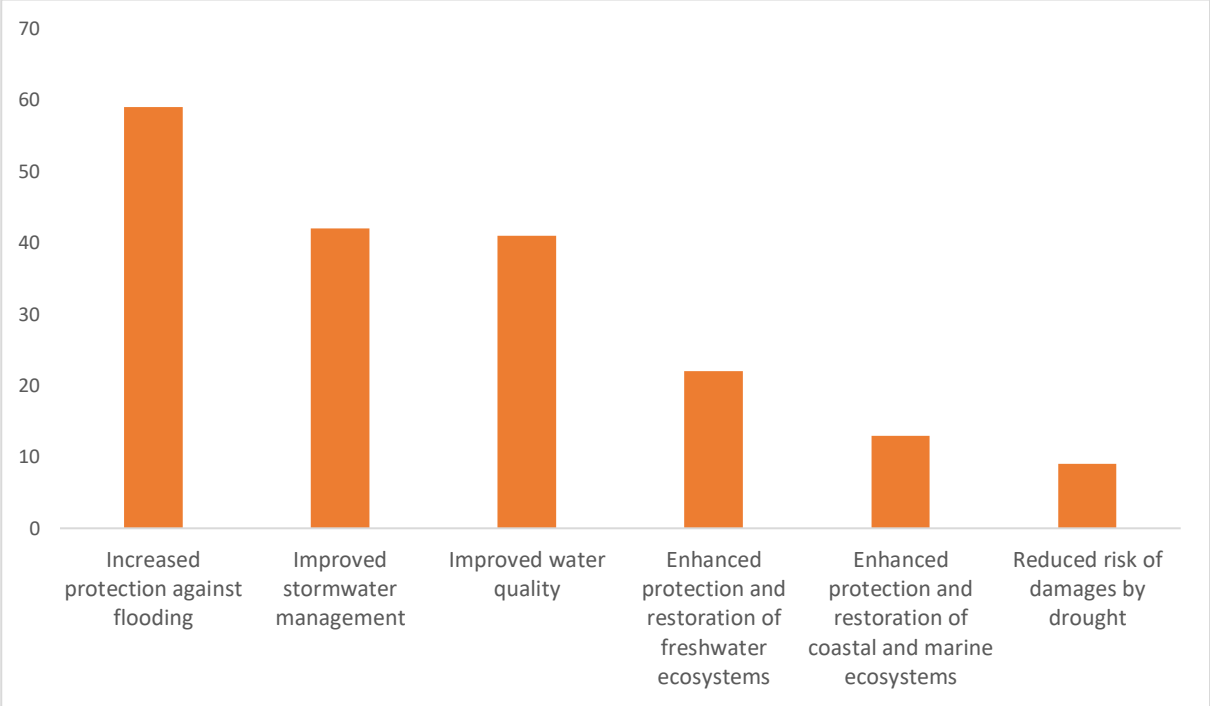

Figure 8: Impacts related to water management as reported by non-European cases.

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58% of projects also cited improvements in environmental quality as a result of NBS implementation, with benefits most frequently linked to improved air quality (30%) and/or soil protection (28%) (Figure 9).

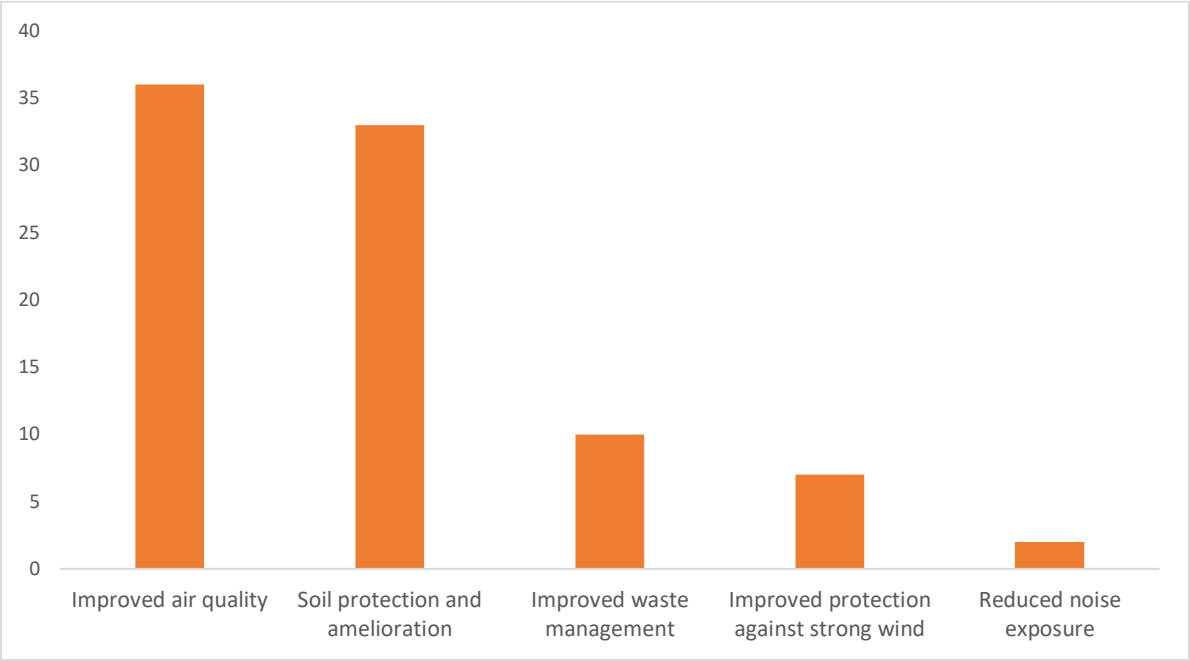

Figure 9: Impacts related to environmental quality reported by non-European cases

A project example for delivering multiple environmental benefits is presented in Box 4.

Box 4: ACROS Fukuoka Prefectural International Hall Step Garden (Fukuoka, Japan)

The 'Step Garden' is a 14-tier green roof atop the Asian CrossRoads Over the Sea (ACROS) Fukuoka Prefectural International Hall in Fukuoka, Japan. In developing the site, the architect wanted to "the maximum extent possible...to give back to Fukuoka's citizens all the land the building would subtract from the city". In combination with Central Park, the rooftop garden is considered the only open green space in the city centre, providing several environmental benefits to people and nature. A temperature survey was conducted, collecting thermal data from the "top, tenth, sixth and fifth levels" of the roof garden, revealing a difference of 15°C between the surface temperatures of the concrete, concluding that the greenery suppresses a rise in the surrounding air temperature. Additional noted benefits include an improvement in local air quality, capturing of rainwater atop the roof garden, and increased biodiversity benefits through inclusion of 37,000 individual plants onto the structure, themselves representing 76 plant species. As opposed to having a conventional building without the inclusion of NBS being developed at the same location, inclusion of NBS onto the structure has not only increased biodiversity present, but likely also reduced biodiversity loss which would otherwise have occurred through construction of a building on a former greenspace.

Source:https://una.city/nbs/fukuoka/acros-fukuoka-prefectural-international-hall-step-garden

2.5.2. Socio-cultural impacts

Regarding socio-cultural impacts, most NBS projects contributed to improved social cohesion and social justice (76%). These impacts were reported in relation to the projects having improved citizen access to green space, facilitating inclusion of locals in the management of urban green space, improving an area's liveability, and through offering increased opportunity for social interaction (Figure 10).

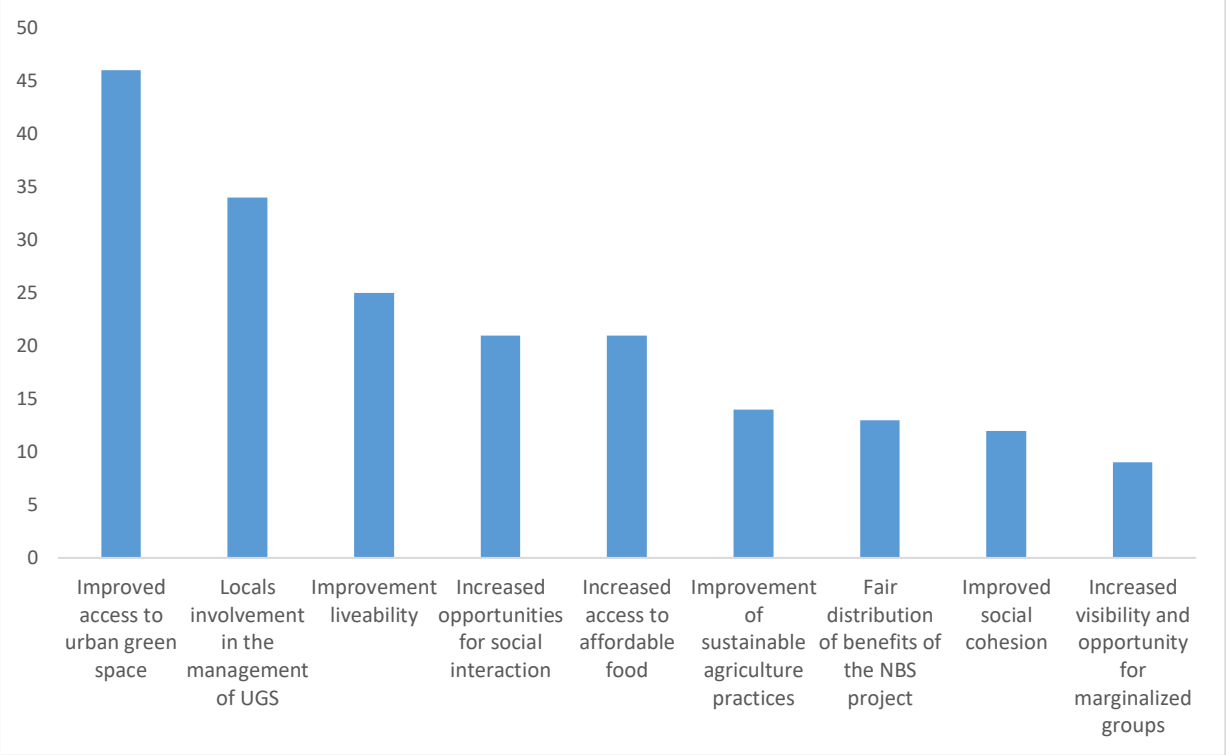

Figure 10. Impacts related to social justice and interaction, as reported by the non-European cases.

Educational benefits were also commonly reported by the non-European NBS cases (72%). These were mostly attributed to improving local residents' knowledge about local flora and fauna, increasing awareness of the benefits provided by nature, and increasing support for education and research (Figure 11). Health and well-being benefits were identified by 39% of

the projects, mainly related to the increase in recreation opportunities. A handful of projects also reported NBS creation supporting physical and mental health (Figure 12).

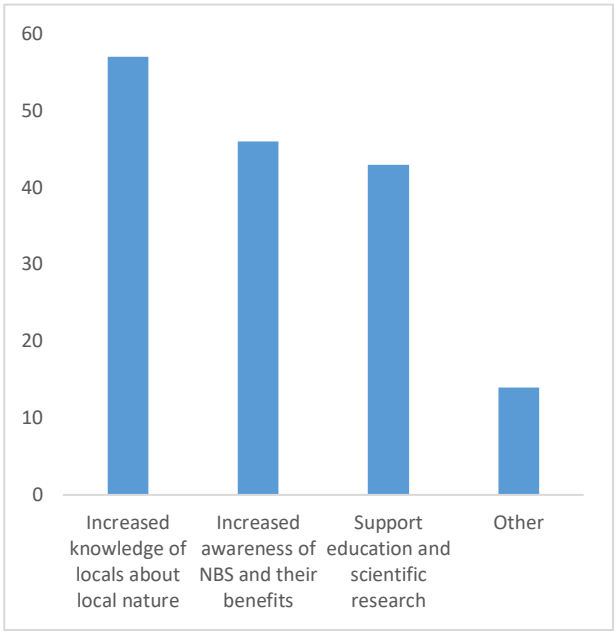

Figure 11. Impacts related to education, as reported by the non-European cases included in the UNA.

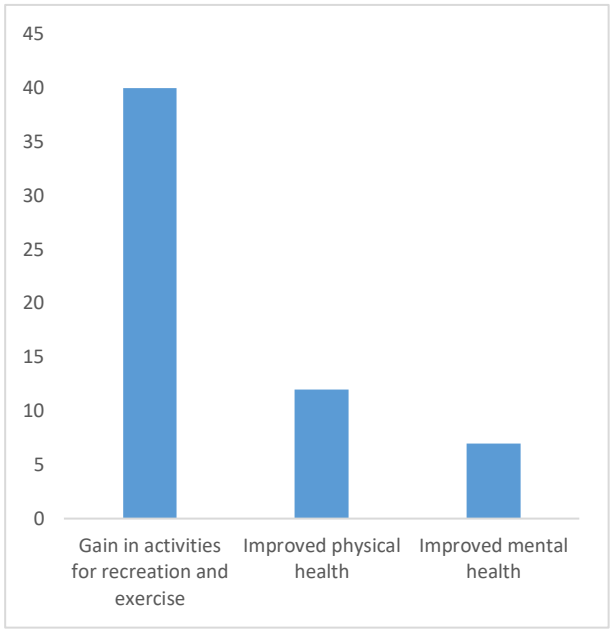

Figure 12. Impacts related to health/well-being, as reported by the non-European cases included in the UNA.

Impacts related to safety were reported by 32% of projects, with the predominant benefit being improved community safety to climate change-induced hazards (Figure 13). Protection of cultural and natural heritage benefits were reported by 27% of projects, primarily through projects increasing people's connection to nature (Figure 14).

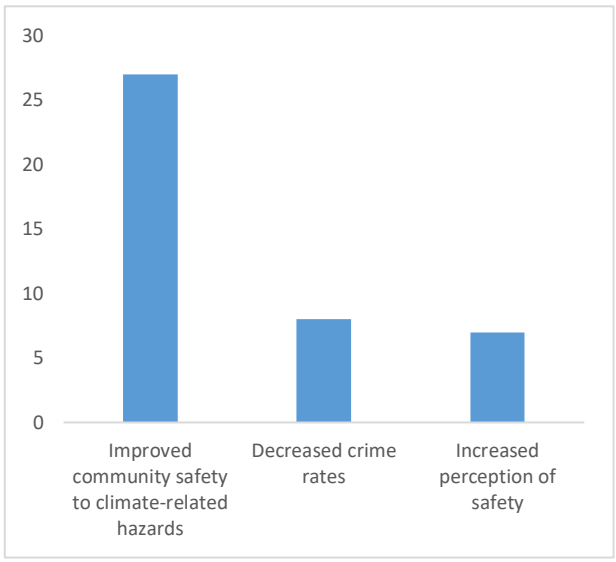

Figure 13. Impacts related to safety, as reported by the non-European cases.

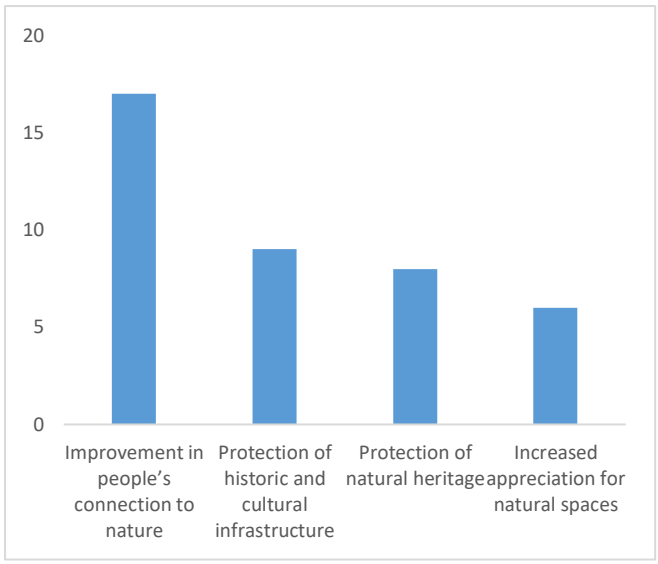

Figure 14. Impacts related to cultural and natural heritage reported by the non-European cases.

An example of social benefits delivered by an NBS project, is presented in Box 6.

Box 5: River rehabilitation and creation of green corridor (Eskişehir, Turkey)

The Porsuk stream divides the city of Eskişehir, Turkey, in two, with a green corridor running along the shores of the stream. The Porsuk stream provided provisioning services and acted as a recreational area in the first half of the 20th century; however, with increased industrial activities, pollution and rapid urbanisation, it became highly polluted, and its ecosystem severely degraded. Within the framework of the 'Eskişehir Urban Development Project', the Natural Disaster Loss Reduction Project (Porsuk Project) has been initiated, focusing on the ecological restoration of the stream, improving water quality, and increasing the resilience of the city against natural disasters (e.g. earthquakes and floods). The project seeks to re-establish the stream's environmental and social role in the city. In addition to environmental benefits, the NBS has also improved people's perception of flood risk, and has increased residents' access to public green spaces. Through provision of a park area and associated amenities (e.g. eating and viewing areas, sports fields, children's playgrounds, and walking and cycling paths), recreational opportunities have been created in many forms, increasing suitability and usability for people from any age group and/or functional diversities.

Source: https://una.city/nbs/eskisehir/river-rehabilitation-and-creation-green-corridor

2.5.3. Economic impacts

Economic impacts as a result of NBS implementation were not as ubiquitous among non-European case studies as environmental and socio-cultural impacts. A total 59% of the non-European projects achieved or anticipated economic impacts, in contrast to 99% reporting environmental and/or socio-cultural benefits.

Of those projects which did report economic impacts, the most common were related to either employment opportunities (e.g., through initial development of the NBS, or through ongoing management of the NBS), and the generation of income (e.g., through site visits or selling agricultural products) (Figure 15). Other impacts referred to the improvement of agricultural production either for profit or subsistence, sustainable tourism, development of deprived areas or in relation to the reduction of management costs of urban nature.

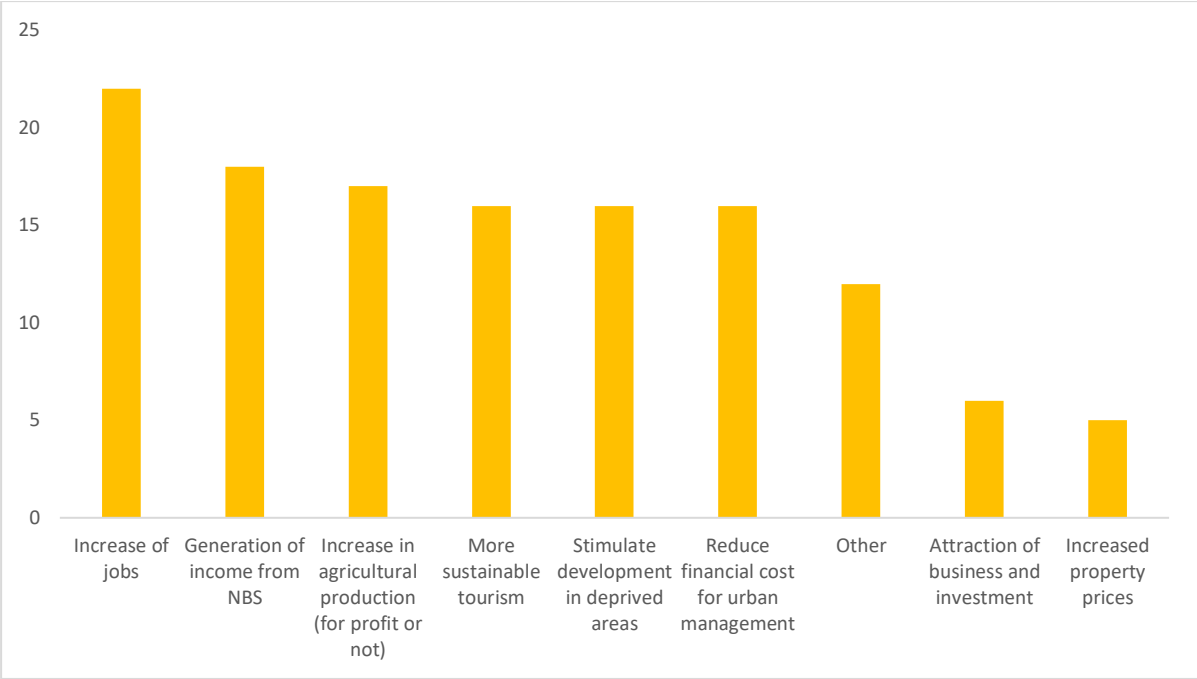

Figure 15. Economic impacts as reported by the non-European cases.

A project example, which delivered economic benefits is presented in Box 5.

Box 6: Cheonggyecheon Stream Restoration Project (Seoul, South Korea)

The Cheonggyecheon Stream Restoration Project saw the dismantling and removal of an elevated freeway and uncovering of a 5.84km section of the Cheonggyecheon historic stream in the centre of Seoul. The restoration has provided environmental, social, and economic benefits within its immediate proximity. Relevant economic impacts reported by the project include increased employment opportunities and the stimulation of development in an otherwise "declining" downtown area, coupled with increased attractiveness to business and investment ventures. Property prices in the area have also increased, at approximately double the rate of property price increases in other areas of Seoul, with a rise of 30-50% for properties within 50 meters of the restoration project

Source: https://una.city/nbs/seoul/cheonggyecheon-stream-restoration-project

3. The potential of NBS to tackle the climate crisis through their deployment in developing countries

In cities there is increasing emphasis on NBS that can simultaneously address multiple societal challenges like climate change, whilst also working with, and for, nature. NBS are therefore envisioned as opportunities to tackle distinct challenges (e.g., climate adaptation, biodiversity loss, stormwater management) in an integrated way. This implies synergies between and benefits for ecosystems and people.

The effectiveness of NBS in tackling critical climate is inherently linked to how adequate and timely is society's response to the need for protecting and sustainably managing ecosystems locally, and also at higher scales.[41] Systematically mapping and assessing the cumulative effects of NBS is therefore critical for understanding how they can address climate change-induced challenges.

Since NBS are increasingly used for climate mitigation and adaptation, there is a growing body of evidence of their effects. However, to date the evidence tends to be concentrated on the benefits of NBS in high-income countries, typically in temperate climatic zones. Evidence and understanding of NBS impacts and benefits in developing countries remains inadequate. To address some aspects of this gap, this section provides an overview of known climate change benefits of NBS projects implemented in middle and lower-income countries across Africa, Asia, Latin America and the Caribbean.

To better understand what type of climate benefits NBS can deliver in developing economies (referring to middle and lower-income economies in Asia, Africa, Latin America and the Caribbean), and what are associated implementation characteristics, this section covers the following:

- Climate-relevant impacts and indicative effectiveness of NBS implementation in developing countries, with a focus on adaptation;
- Differences between the implementation of climate-focused NBS projects in high-income versus developing countries; and
- implementation and governance characteristics which might increase the impact of NBS.

[41] E. Cohen-Shacham et al., "Nature-Based Solutions to Address Societal Challenges." (Switzerland, 2016), https://doi.org/10.2305/IUCN.CH.2016.13.en.

3.1. Impacts and indicative effectiveness of urban and peri-urban NBS for addressing climate change in developing countries

As shown in section 2.5.1., climate change-related benefits of NBS include, among others, the reduction of the effects of heatwaves or urban heat islands; prevention of flooding and/or management of runoff, and other ways of reducing the exposure associated with or direct impacts of climate change[42]. Besides climate adaptation, NBS can also contribute to mitigation goals via the sequestration of carbon dioxide from the atmosphere either in the form of plant biomass or soil carbon.

This section provides examples of how NBS can contribute to the fight against climate change in urban and peri-urban environments.[43] The impacts reported may be based on quantitative data, qualitative observations or their combination. Some of the impacts are categorised as 'expected', meaning that either the NBS implementation is currently underway and impacts are yet to be measured, or that no impact assessment has been done.

3.1.1. Climate change mitigation and adaption benefits

Nature-based climate mitigation projects tend to focus on carbon sequestration and the reduction of carbon footprints through promoting absorption of carbon dioxide by vegetation and soil.[44] Projects in the UNA include examples where NBS implementation has resulted in carbon sequestration as afforded through the plantation of large-scale, densely packed forests of native species (Lahore, Pakistan);[45] wetland preservation (Kotte, Sri Lanka);[46] mangrove rehabilitation (Paramaribo, Suriname);[47] and implementation of green walls for absorption of greenhouse gas emissions and also cost reduction due to improved building thermal regulation (Bogotá, Colombia. [48] In addition to contributing to carbon sequestration,

[42] Nathalie Seddon et al., "Understanding the Value and Limits of Nature-Based Solutions to Climate Change and Other Global Challenges," *Philosophical Transactions of the Royal Society B: Biological Sciences* 375, no. 1794 (2020), https://doi.org/10.1098/rstb.2019.0120; E. Iwaszuk et al., *Addressing Climate Change in Cities – Catalogue of Urban Nature-Based Solutions*, *Ecologic Institute and Sendzimir Foundation*, 2019, https://www.ecologic.eu/17229; Cohen-Shacham et al., "Nature-Based Solutions to Address Societal Challenges."; Raymond et al., "An Impact Evaluation Framework to Support Planning and Evaluation of Nature-Based Solutions Projects," 2017, https://doi.org/10.13140/RG.2.2.18682.08643.

[43] A similarly varied, but different, suite of NBS interventions may be considered appropriate for implementation in rural areas and other ecosystems such as oceans or grasslands. Examples include the restoration of coral reefs and seagrass, the prevention of deforestation of primary forests, the reinforcing of marine protected areas and the promotion of sustainable agricultural approaches on degraded land.

[44] Sandra Naumann et al., "Nature- Based Approaches for Climate Change Mitigation and Adaptation. The Challenges of Climate Change - Partnering with Nature," 2014, 1–22, http://ecologic.eu/sites/files/publication/2014/eco_bfn_nature-based-solutions_sept2014_en.pdf.

[45] https://una.city/nbs/lahore/liberty-market-forest

[46] https://una.city/nbs/sri-jayawaradenepura-kotte/beddagana-wetland-preservation

[47] https://una.city/nbs/paramaribo/building-nature-mangrove-rehabilitation

[48] https://una.city/nbs/bogota/santalaia-building-vertical-garden

vegetation cover can also provide additional co-benefits, such as improving air quality, increasing biodiversity and strengthening urban resilience to climate-induced hazards.

NBS also contributes to climate change adaptation and disaster risk reduction. These benefits are largely achieved by reducing societies' exposure or sensitivity to climate hazards and improving their adaptive capacity[49]. Historically, climate-induced disasters and risk reduction relied heavily on grey infrastructure, for example, dikes, sea walls and flood gates. While many middle and low-income economies are especially vulnerable to climate impacts, they typically have limited resources to invest in climate change adaptation. However, the systematic deployment of NBS can provide an alternative means by which to address immediate adaptation needs, at a more acceptable cost and while also producing additional co-benefits.

The UNA includes many innovative examples of purpose-designed NBS that address climate change from developing countries. For example, the Dodoma's Foodway initiative (Tanzania) [50] is expected to improve food security and strengthen biological diversity in agriculture, while also reducing the impact of extreme climate events due to rising temperatures, longer dry spells, more intense heavy rainfall and sea-level rise. The project achieves such impacts through allotments and community gardens and the promotion of regenerative agriculture.

Similarly, multi-purpose green belts and corridors strengthened coastal protection in Batticaloa, Sri Lanka [51] and enhanced protection against adverse weather in Nur-Sultan, Kazakhstan.[52] Purposefully designed NBS can lower local temperatures and the impact of heat waves, as illustrated by large urban parks (Bangkok, Thailand)[53] or green walls which improve indoor thermal regulation (Montevideo, Uruguay).[54] Further examples include increased flood protection through river restoration (Singapore;[55] reduced risks associated with droughts (Cape Town, South Africa);[56] and mitigating the effects of sea-level rise (Victoria, Seychelles).[57]

3.1.2. Effectiveness of climate-focused NBS projects

Due to the limitations of impact assessments methods and inadequate monitoring, measuring the effectiveness of NBS in achieving their goals, and their overall contribution to climate change risk or impact reduction is difficult.

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[49] EEA, *Nature-Based Solutions in Europe*, 2021, https://www.eea.europa.eu/publications/nature-based-solutions-in-europe.
[50] https://una.city/nbs/dodoma/dodomas-foodway
[51] https://una.city/nbs/batticaloa/green-belt-costal-protection
[52] https://una.city/nbs/nur-sultan/green-belt-nur-sultan-city
[53] https://una.city/nbs/bangkok/chulalongkorn-centenary-park
[54] https://una.city/nbs/montevideo/celebra-vertical-garden
[55] https://una.city/nbs/singapore/bishan-ang-mo-kio-park-kallang-river-restoration
[56] https://una.city/nbs/cape-town/atlantis-water-fund-pilot-project
[57] https://una.city/nbs/victoria/ecosystem-based-adaptation-climate-change

To contribute to the debate on what constitutes an effective NBS in the context of climate change, an analytical method was developed for this report by which the projects included in the UNA could have their expressed climate change impacts systematically evaluated.

First, NBS projects were selected for analysis if they fulfilled the following criteria:

- implemented in a developing country;
- identified a climate-focused goal; and
- have documented evidence that NBS implementation resulted in climate change adaptation or mitigation benefits.

Within our overall sample of 1140 projects, 114 NBS projects met these criteria. It was found that 84 NBS projects with explicit climate goals (75% of all assessed) also documented climate-related impacts. Whilst the remaining 25% might also have had climate-related impacts, these were not reported for one of several possible reasons: the project still in its planning phase or undergoing implementation; incomplete documentation; or inadequate impact assessment methodology.

The ***second*** step focused only on projects, which reported positive impacts related to climate change. The strength of the climate impacts was analysed and categorized as strong positive, moderate, small or unclear.

It was found that 54% of projects (45 of the 84 in total) had a strong positive contribution to solving climate-related problems (Figure 16). These projects represent 39% of the total number of projects in the middle and lower-income economy countries (of 114 NBS projects). As an example of a project in this category, the "Green Cloud Project"[58] in Shenzhen (China), reported that implementation of the NBS contributed to improved stormwater management through the installation of green roofs, providing 65% of adequate water retention capacity. Stormwater management also helped water absorption, purification, storage and reuse. Additional documented impacts include the regulation of indoor temperature, urban heat island effect reduction, improved air quality, and recreation of an original natural habitat of the city, thus enhancing biodiversity in the area. In addition to being viewed as a "water sponge", the project is also seen as "sponge" or catalyst for community engagement, education, and culture.

An additional 31% of the projects provided moderate contributions to climate change impacts. The "Urban Micro-Lungs" project in Amman (Jordan) is expected to contribute to reducing the

[58] https://una.city/nbs/shenzhen/green-cloud-project-gangxia-1980

heat island effect in the area through a pocket park.[59] 15% of the projects included in the sample provided only a minor contribution or their effect was unclear.

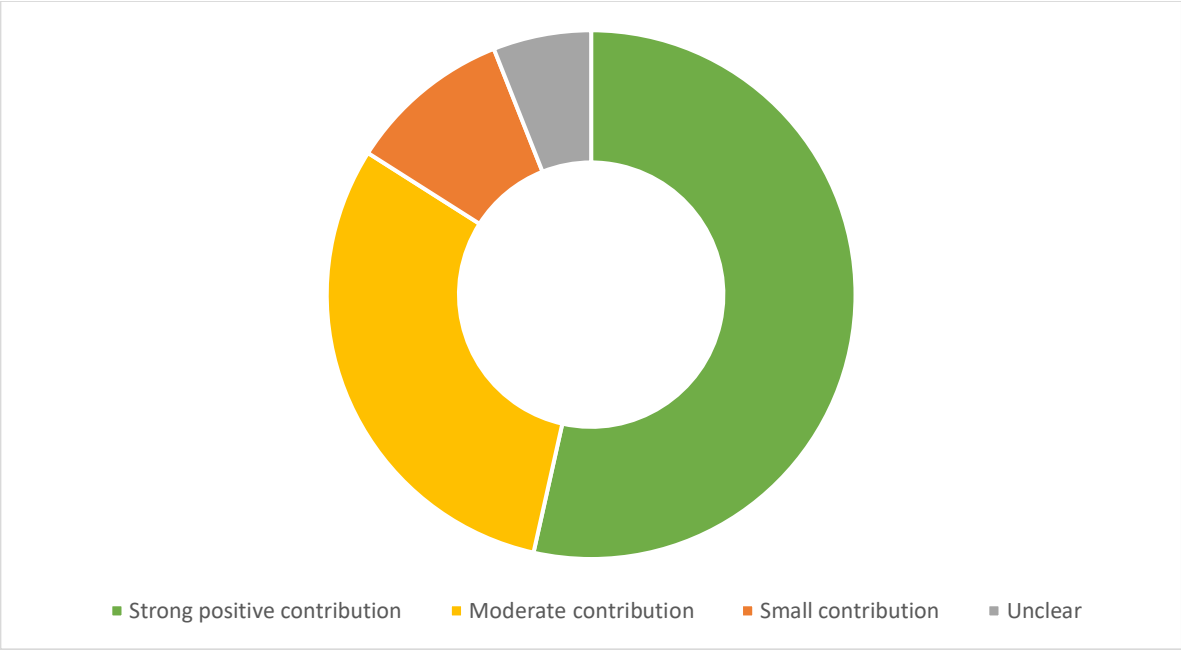

Figure 16. Effectiveness of NBS projects with climate-oriented impacts

For the ***third*** step in the analysis, the characteristics of those 45 projects (54% of the total) which demonstrated a strong positive contribution to solving climate-related challenges were analysed in more detail.

In addition to having tackling of climate change challenges as their main goal, 100% of these projects also targeted green space and biodiversity objectives. 80% also targeted water management; and 64% also included improved environmental quality. Most projects (80%) aimed at creating new green areas and the ecological restoration of degraded ecosystems, commonly at a larger scale: district or neighborhood (49%) but also at the metropolitan or urban level (31%).

When examining the types of NBS implemented in these high-impact cases, most include the creation or restoration of one of the following:

- large urban parks or forests (e.g., "Restoring Dry Deciduous Coastal Forest and Mangroves" in Madagascar[60]);
- green corridors (e.g., "Green Belt of Medellin" in Colombia);[61]
- wetlands (e.g., "Beddagana Wetland Preservation" in Sri Lanka); [62]

[59] https://una.city/nbs/amman/urban-micro-lungs
[60] https://una.city/nbs/mahajanga/restoring-dry-deciduous-coastal-forest-and-mangroves
[61] https://una.city/nbs/medellin/green-belt-medellin
[62] https://una.city/nbs/sri-jayawaradenepura-kotte/beddagana-wetland-preservation

- street tree projects (e.g., “Greening Kampala” in Uganda);[63]
- and/or rivers or channels (e.g., “Bishan-Ang Mo Kio Park & Kallang River Restoration” in Singapore);[64]

Analysis of their governance arrangements showed that 40% of these projects were government-led, 31% were led by non-government actors, and 29% were co-governed by both governmental and non-governmental players (the latter mostly NGOs and the private sector). Projects with strong climate-impacts were therefore shown to be more likely government-led than those which had a climate-goal but only medium, weak or no impacts, and also those which did not have a climate-goal at all. Actors who initiated these NBS projects were most commonly local governmental bodies or the municipality (53%), followed by private companies (24%) and research institutions/universities (22%).

3.2. Implementation differences between climate-focused NBS projects in high-income versus developing countries

To better understand which implementation and governance characteristics may have a stronger potential in delivering high-impact NBS cases, we also studied the differences between NBS projects addressing climate change related challenges in high-income versus middle and low-income countries. For the latter, we considered 114 climate-focused projects in developing economies of Asia, Africa, Central and Latin America. We examined these projects to understand their goals, implementation characteristics and governance arrangements (presented in Section 2). Having understood these aspects, we compared them with 309 climate-focused NBS projects from high-income countries, mostly in Europe, which were already listed in the UNA.

3.2.1. Sustainability challenges and project goals

When comparing climate focused NBS projects in developing versus high-income countries (Figure 17), similarities can be seen in what project goals are framed relative to the sustainability challenges the project aims to address. Specifically, similarities can be seen regarding the following types of goals:

- increasing green space and biodiversity;
- promoting inclusive governance; and
- improving environmental quality.

[63] https://una.city/nbs/kampala/greening-kampala
[64] https://una.city/nbs/singapore/bishan-ang-mo-kio-park-kallang-river-restoration

There are however some noticeable differences between project goals in developing versus high-income countries. NBS projects with climate objectives in developing countries tend to more frequently address water management, [65] social justice and cohesion, coastal protection,[66] and to some extent, economic development. However, in comparison with high-income countries, these projects seem to focus less on addressing sustainable consumption and production, urban regeneration, health, and wellbeing and/or cultural heritage.

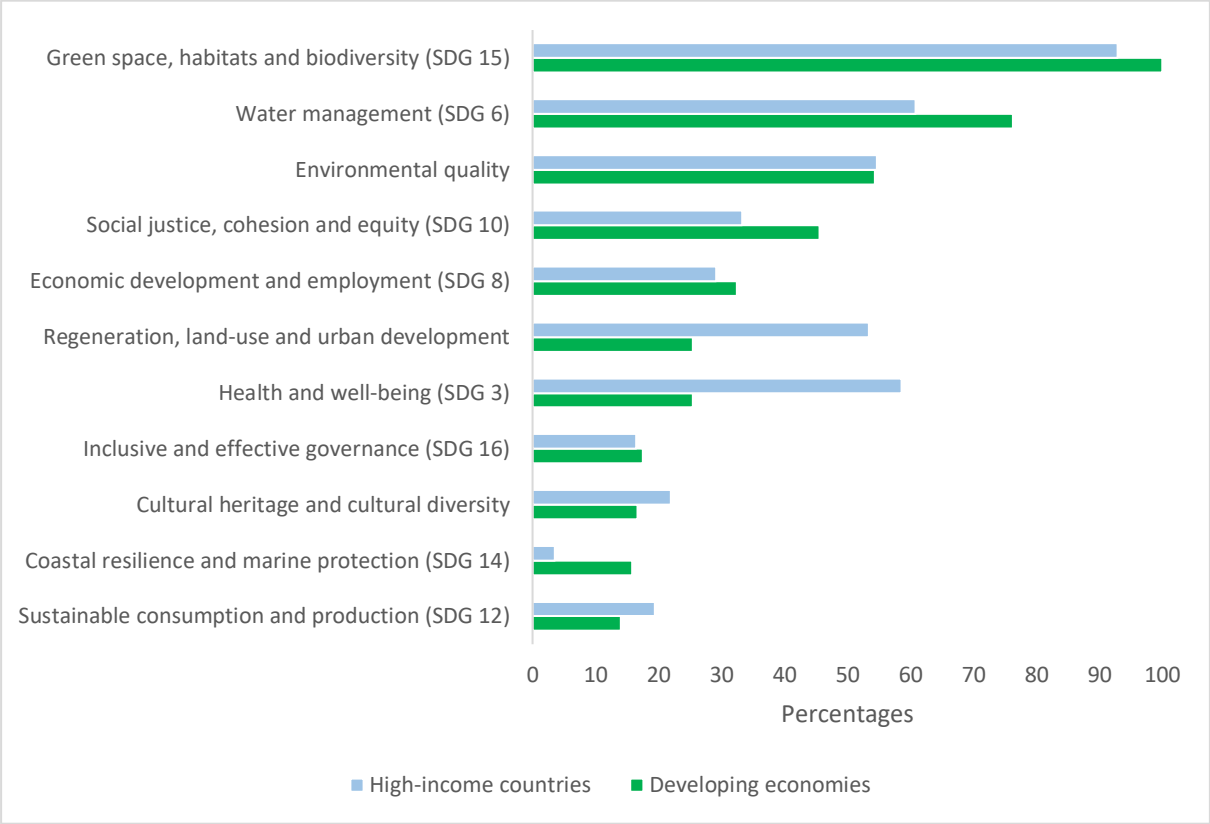

Figure 17. Comparison of sustainability goals addressed by climate-focused NBS projects in high-income versus developing countries.

3.2.2. Implementation characteristics of projects addressing climate change challenges

Climate-focused NBS projects in developing economies tended to occupy a larger area than those in higher-income countries. The former were also more frequently implemented in natural heritage areas, protected areas, agricultural land and residential spaces as compared to NBS. Climate-focused NBS in high-income economies were more likely to take place on or in buildings, in existing public green spaces and in industrial areas.

[65] Methodological implication: this difference might be related to the methodological approach of identifying projects that aimed to address climate adaption or mitigation issues in the GS database extension. As that methodological choice in the selection of projects, perhaps influences selecting projects that tackle water management due to goals related to increasing resilience against floods and droughts.
[66] Another methodological implication as the cities in the non-European cities includes more coastal cities.

With regards to their urban setting(s), for NBS in developing economies it was more typical to include blue areas (e.g., riverbanks, mangroves), likely related to the higher number of projects to address water management problems (Figure 18). The data also show that NBS in high-income economies were more likely to include nature on buildings (e.g., green roofs or façades); in combination with grey infrastructure (e.g. street trees or green parking lots); and natural solutions to water management (e.g. swales or Sustainable Urban Drainage Systems (SUDS)). NBS associated with community gardens and urban parks or forests were equally frequent in both high and lower income countries in the sample.

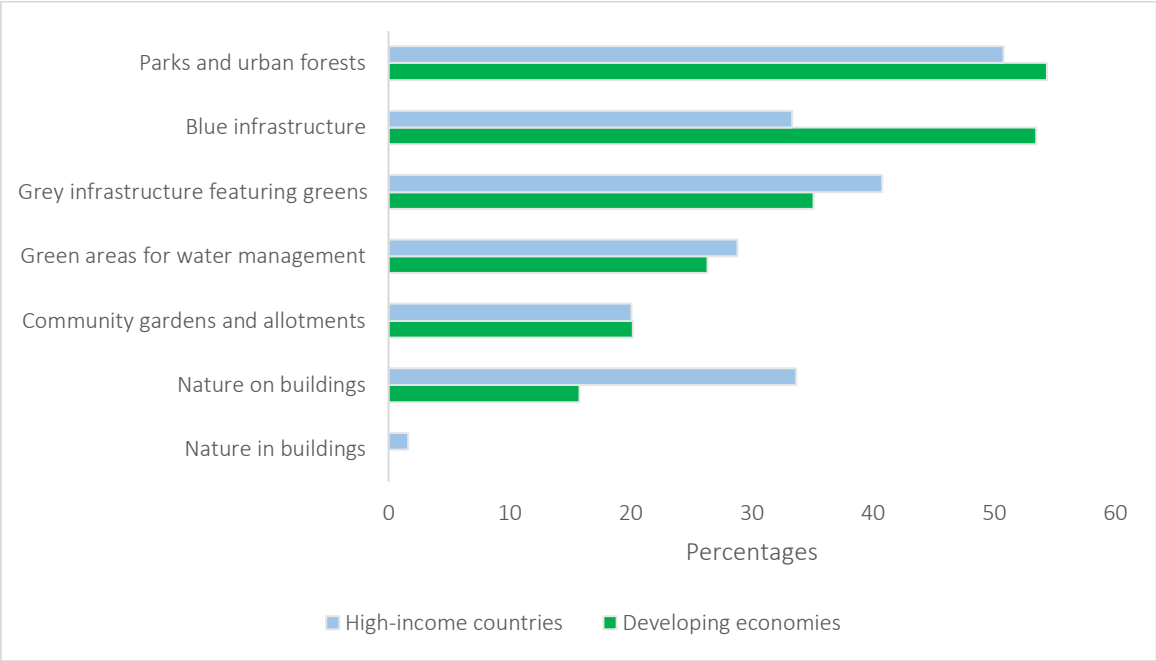

Figure 18. Urban settings of the climate focused NBS projects in high-income versus developing countries.

When assessing implementation focus, NBS in middle and lower-income countries generally have a stronger emphasis on the ecological restoration of degraded ecosystems, the management of rivers and coastal protection, and the protection of natural ecosystems (Figure 19). These projects were also more likely to deliver knowledge creation activities, for example, through provision of nature protection education. These findings illustrate that significant effort has been undertaken in these countries to protect and conserve existing ecosystems, habitats, and biodiversity. In contrast, project implementation in higher-income economies suggest larger emphasis on the creation of new urban green space.

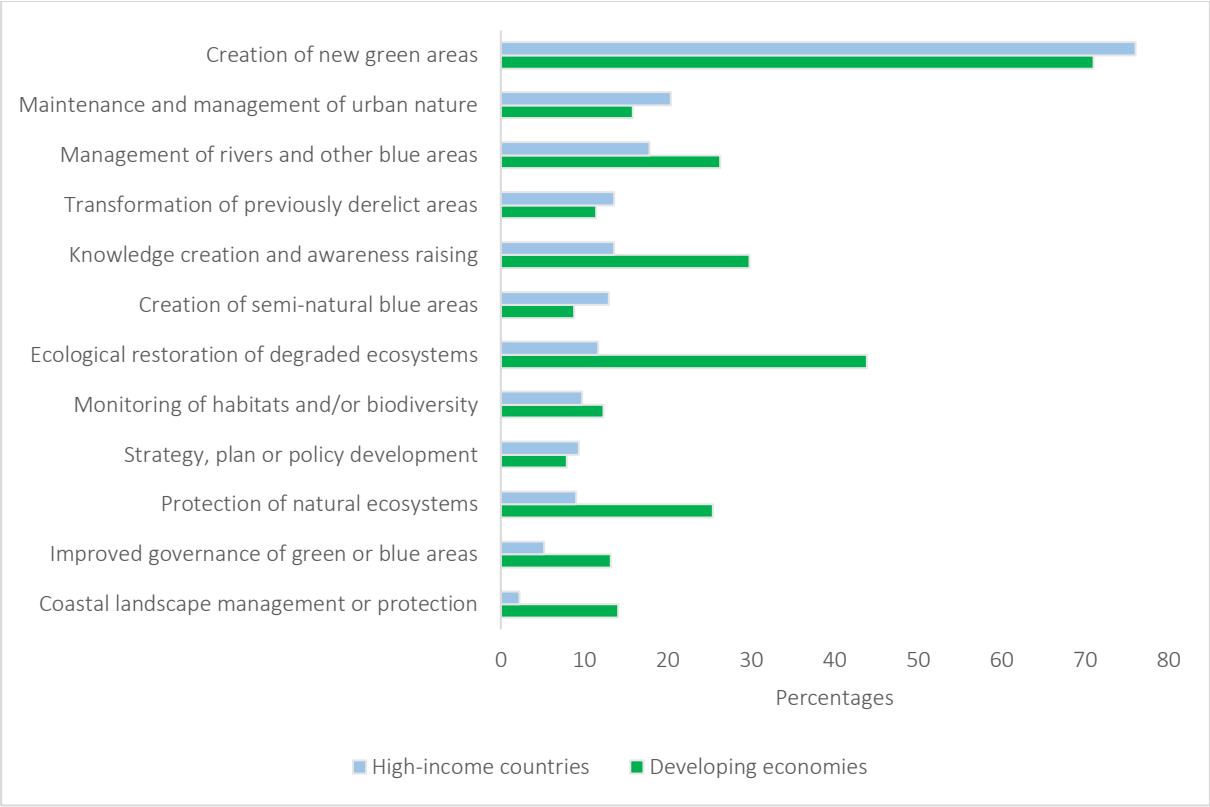

Figure 19. Project type comparison of the climate-focused NBS projects in high-income versus developing countries.

Analysis of the innovation type(s) (technological, social or system) associated with the sampled projects showed that technical innovations were more common in both developing and higher-income economies in explicitly climate-focused versus non-climate NBS. Among NBS with a climate change goal, 65% in high-income, versus 61% in developing economies involved technological innovation. Conversely, only 54% of NBS without a climate change objective included technological innovation. This indicates a higher need for technological innovation in projects which are intended to address climate objectives. Social, for example, governance or cultural innovation, are also relatively common in climate-focused projects in developing economies (60%) but less common in high-income countries (45%). System innovation remains limited across all types of countries.

Across both high income and developing economies, climate focused NBS were more likely to be implemented via a co-governance, involving both governmental and non-governmental actors: 44% of NBS in high-income vs. 46% in developing economies. The share of government-led projects was approximately 30% for both types of countries. A smaller number of projects, around 25%, were implemented exclusively by non-governmental actors.

Regarding projects that aim to address climate change-associated challenges, financing information was often not publicly available. In cases where financial information was available, it was apparent that projects often required large budgets exceeding €4,000,000 (Figure 20). Specifically, 53% of projects with available budget data in high-income economies

and 42% of projects in developing economies required a budget of this calibre. In contrast, relatively few projects had budgets less than €10,000. This budget bracket was applicable to 7% of projects in developing and 2% of projects in high-income economies.

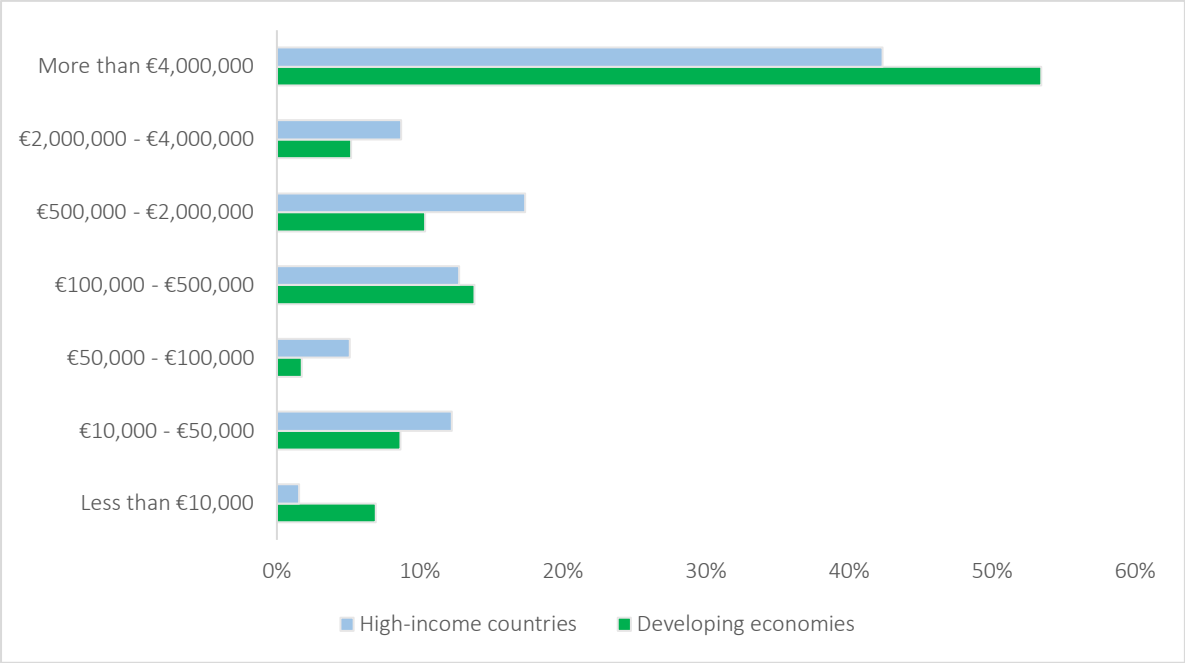

Figure 20. Budget comparison of the climate-focused NBS projects in high-income versus developing countries.

3.3. Implementation and governance characteristics that can increase the impact of climate-focused NBS

Building on the results of section 3.1 and 3.2, we aimed to identify implementation factors and governance characteristics that can potentially increase the delivery of high-impact cases with benefits for climate. To identify these factors, we made use of various statistical and machine learning methodologies, including multivariable analysis, clustering, random forest decision tree analysis and linear regression analysis.

Highlights of the results of this analysis are presented below, while methodological details are available upon request.

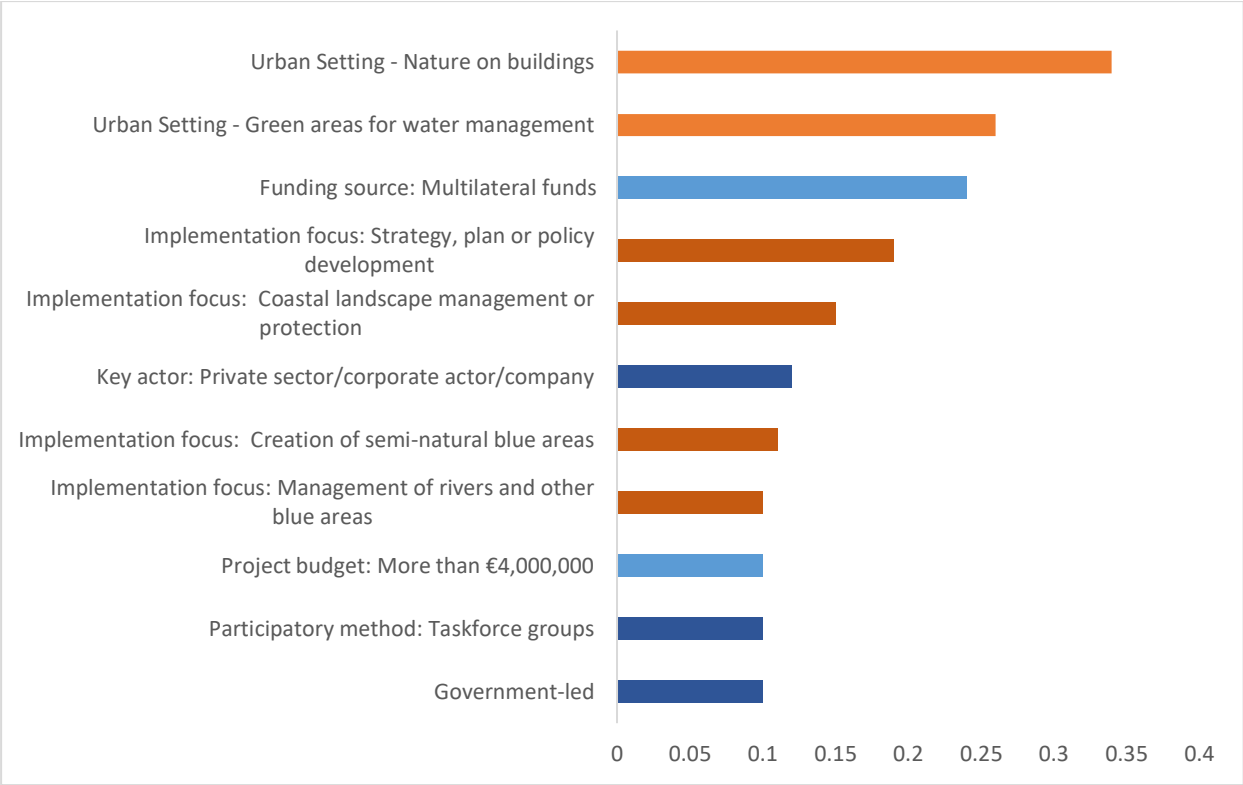

Figure 11: NBS implementation and governance characteristics predicting the delivery of climate impacts

3.3.1. Implementation characteristics

In terms of goal setting, cluster analysis concluded that NBS projects are more likely to address climate change-related challenges in combination with water management, coastal resilience, environmental quality, or economic development. Thus, climate-related goals were often established together with other goals focusing on these challenge areas.

Among the different types of NBS, the analysis identified three categories which are more likely to deliver climate impacts:

- green areas for water management;
- blue infrastructures; and
- nature on buildings, such as green roofs and green walls.

Green areas for water management are likely to result in improved stormwater management and increase flood protection. Blue infrastructures showed strong potential to deliver increased protection against flooding and strengthen communities' capacity to address climate hazards. Green areas for water management exhibited a stronger correlation with lowering local temperatures.

Besides the creation of green areas for water management and on buildings, the assessment also suggests that projects aiming for the protection of natural or the ecological restoration

of degraded ecosystems and the management of rivers and blue areas are somewhat more likely to have climate-related benefits.

A weak correlation was also identified between the application of technological innovations and the delivery of climate impacts, especially for improved stormwater management and increased protection against flooding.

A summary of implementation characteristics, which are likely to increase the delivery of climate-related benefits is summarized in Table 5.

Table 5: Implementation features of NBS projects with higher likelihood to deliver climate impacts

Implementation aspects	Features
Established goals	Climate change Water management Environmental quality or Economic development
NBS types	Green areas for water management Nature on buildings Blue infrastructure
Project focus	Protection of natural ecosystems Ecological restoration of degraded ecosystems Management of rivers and blue areas
Innovation	Technological innovations related to flood and stormwater management

3.3.2. Governance characteristics

Overall, only a weaker correlation could be identified between the projects' governance characteristics and the delivery of climate impacts.

The analysis indicates that government-led projects, especially those implemented by local governments, are somewhat more likely to provide climate impacts. When implemented by non-governmental actors, the role of corporations stood out as potentially significant for the increased delivery of climate benefits.

The results also suggest that relevant national and local strategies and policies, such as those promoting green infrastructure, spatial planning, or water management policies, could act as drivers for implementing NBS projects with climate-related benefits. In addition, the involvement of task forces in NBS implementation could also positively influence the delivery of climate impacts.

Regarding financing, projects with a budget above EUR 4 million had more substantial potential to deliver climate impacts, especially increased protection against flooding. However, this result might have been influenced by stronger monitoring and documenting capacity of projects with a larger budget.

In addition, the involvement of multilateral funds (provided by organizations such as the World Bank) represented a potentially relevant stimulus for delivering climate-related benefits. To some extent, this may be due to the stronger monitoring and reporting requirements of projects supported by multilateral funds. More emphasis on monitoring and reporting may facilitate impact assessment. At the same time, multilateral organizations are also more likely to explicitly request the delivery of climate-related benefits and through this influence project design.

The results also highlighted the potential importance of innovative financing mechanisms: projects that involved private financing (e.g., from private investment companies, banks, or pension funds) to deliver and maintain NBS were more likely to result in climate-related benefits.

Table 6: Governance characteristics of NBS projects with higher likelihood to deliver climate impacts

Governance aspects	Features
Governance arrangement	Government-led
Key actors	Local governments Private companies or corporations
Drivers of implementation	National or local policies Taskforce groups as stakeholder involvement methods Multilateral funds Private financing

4. Lessons for policy making and key messages addressing COP-15 priorities and the upcoming UNFCCC COP-27

NBS cases studied during the global extension of the Urban Nature Atlas - including the many examples identified by participants who attended the successive British Academy workshops - illustrate that NBS have a realistic potential to contribute to the sustainability transformation of cities. They are present in and contribute to a wide range of urban contexts, making cities more liveable and more resilient to the impacts of climate change. They highlight that NBS should serve as an inspiration for the research, policy, and practitioner communities. However, even though NBS can synergistically address climate and biodiversity challenges, it is important that organisations such as the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), and their key constituents work together more closely and leverage the opportunities presented by their respective Conference of the Parties (COPs) to coordinate and align agendas. This reflects the understanding that mainstreaming and upscaling NBS takes place in a multi-level governance framework, where each level can not only enable, but also create barriers to NBS development.

Besides the potential to address both climate change and biodiversity challenges, NBS also have additional benefits. Many of these benefits, whether related to environmental, economic, or human wellbeing aspects, are directly linked to the SDGs. NBS therefore have the potential to multi-solve sustainability problems, with minimal risk of negative side-effects or externalities. These attributes make NBS worthwhile candidates for infrastructure development programmes, not only in high-income economies, but also in the cities of middle and lower-income countries.

However, recognising this potential is not enough. Recognition must be accompanied by an understanding of the ways in which NBS can be implemented to effectively address these challenges. Whilst examples exist of NBS which address climate change and biodiversity challenges, the lack of systematic monitoring often renders the evidence base weak, which can undermine the business case. In the short run, this can be addressed in part by collecting a more representative sample of case studies. However, a real solution would require improving and mainstreaming monitoring and impact assessment practices and capacity. Going a step further, rather than simply assuming that what gets measured get done, it would also require embedding evidence about NBS impacts - and how appropriate design of NBS can help to maximise these impacts - in planning, investment decisions, and management.

While NBS have been most often discussed in the scientific literature in the context of high-income countries, NBS are clearly a global phenomenon. Although some are associated with high-end development projects, NBS have the potential to offer cost-effective solutions to

multiple sustainability challenges that are most acute in the fast-growing but poorer cities of the world. Even more importantly, through their contribution to human well-being, NBS may be most needed in contexts where they are thought of as the least affordable: the urban peripheries and the slums where a significant majority of marginalised people live. While some results of the research conducted in affluent cities may be universally applicable, the conditions which exist in cities outside of Europe, particularly those less affluent ones, may be fundamentally different and therein warrant further attention being paid to their individual context. It is only through more attuned attention being paid to potential variations within middle and lower-income economies in relation to drivers; environmental problems; governance set-ups and financing models, including how these factors may vary across impoverished parts of cities; infrastructure; and the tangible and intangible heritage assets which are typical of cities, that can turn the vision of a world of NBS into a reality.